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Proceedings....

Eastern Experiment Station Collaborators' Conference on

Agricultural and Processing Wastes In the Eastern Region: A Perspective

December 1—3, 1970

Philadelphia
Pennsylvania

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UNITED STATES DEPARTMENT OF AGRICULTURE

This conference on agricultural and processing wastes in the Eastern region was one of a series of annual collaborators' conferences organized by the regional marketing and nutrition divisions of the Agricultural Research Service, U. S. Department of Agriculture. The collaborators are staff representatives of the State Agricultural Experiment Stations in each of the four regions. To assure depth and breadth in subject matter, a single area of important research is selected for each conference.

Views expressed in these summaries of papers presented before the Eastern Experiment Station Collaborators' Conference on Agricultural and Processing Wastes in the Eastern region are not necessarily those of the U. S. Department of Agriculture. Requests for further information must be sent to the speakers. Mention of commercial products or firms does not imply USDA recommendation or endorsement over others not mentioned.

June 1971

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WELCOMING REMARKS

I. A. Wolff
Eastern Marketing and Nutrition Research Division[1]
Agricultural Research Service, USDA

I extend a warm welcome to our collaborators, other Station and University staff members who may have accompanied them, to our ARS visitors and to our other guests. We would like your visit to be professionally profitable and stimulating, and pleasant as well.

Meetings of EMNRD Collaborators

Our annual collaborators' conferences started over 20 years ago with the thought that there should be useful interactions in selected program areas between scientists at EMNRD and those who are stationed in the various States of our region. These interactions involve first some knowledge of one another's programs, and then cooperation in any areas where it is mutually felt that working together will facilitate or accelerate progress. The current climate for scientific research dictates that we make our programs responsive to social needs and national goals and objectives. It is essential not only that our programs be properly oriented but that the public be aware of the implications of our results and of the absolute necessity for certain basic research before true progress and breakthroughs are possible in some difficult and complex applied problem situations. Because of this focus and scrutiny and questioning of where scientists are concentrating their efforts, and with what effectiveness, it is more necessary than ever that we gather in meetings like this one and truly pool our knowledge and collaborate in approaches to problem solving and then tell the public about our accomplishments.

Our format this year is somewhat different than in the past, and deliberately so. We have left tomorrow morning free for you to confer informally with our staff members in areas that interest you. We encourage you to do this. We have provided you with a booklet that describes the various laboratory groups of our Division along with their functions and programs. This should be helpful in selecting those you'd like to visit. General tours of the laboratories can be arranged for those who would like them either in addition to, or instead of, your personal visits. This meeting scheme was concurred in by your Northeast Regional Experiment Station Directors when I had the pleasure of joining with them at their meeting last summer.

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[1] Formerly known as the Eastern Utilization Research and Development Division.

Our program differs from last year's in yet another way. The conference last year on human nutrition--which was excellent in scope and caliber, as I'm sure those of you who were here will agree--was presented largely by invited speakers from outside our immediate organization. This year we ourselves--our staff and the collaborators--are talking about a field of mutual interest in terms of the regional and national problems we see and what we are doing about them. I hope the discussions following the presentations will be helpful (a) in bringing into better focus the problems in agricultural and processing wastes that exist and are common to a number of us, (b) in exchanging information on present approaches being made to those problems, and (c) in devising possible new ways of tackling them.

As indicated, the format and roster of speakers differ from last year's conference. But one similarity is the emphasis on a problem of great current national concern. Among the problem areas of high priority for national goals and objectives have been listed improved nutrition and health, food safety, environmental quality (pollution), human and community development, and foreign trade and development. Last year we directed attention to one of these major areas and this time we have chosen another.

The EMNRD Organization and Program

Those of you who have not been with us before might be interested in a few statistics about the Division. Here in our Wyndmoor laboratory, the EMN Divisional headquarters, we have 321 permanent personnel. In addition we have 43 student trainees from Drexel and Lincoln Universities and 5 postdoctoral research associates. In Washington, D. C., and Beltsville, Md., we have 77 persons engaged in dairy and meat research. We also have 5 staff members at the Red River Valley Potato Processing Laboratory in East Grand Forks, Minn., and 1 at the Pioneering Research Laboratory of Physical Biochemistry in Waltham, Mass. About half of our tobacco research is carried out through contract with the University of Kentucky Research Foundation in Lexington. Our staff includes:

Professional scientific	248	(91 Ph. D.'s)
Professional nonscientific	12	
Supporting	159	
Student trainees	43	
Total	462	(includes temporary employees)

Food research occupies approximately 61 percent of our program and nonfood 39 percent, with the breakdown in each category as follows:

Food	Percent
Dairy	33
Meat	15
Vegetables	8
Fruits	4
Maple	1

Nonfood	Percent
Animal fats	18
Hides	12
Tobacco	9

This does not represent a significant change in major emphasis from the situation a year ago. Our program is divided into 29 coordinated areas of research on a particular problem or technology which we refer to as Research Activities. Within these broad categories are ranged 114 work units under which specific investigations are conducted.

Our recent experience has been similar to that of other organizations in exposure to rising research costs without commensurate budget increases. This is, of course, a challenge to make our research program as efficient as we can and to accomplish a maximum amount with our resources. This we are doing, and I believe we are doing it successfully.

Changes

I might call your attention to a few program changes and impending changes at the Eastern Division. Among new lines of work begun or expanded in the last year are the following:

1. Nutrient enrichment of dairy products. Initial emphasis has been on fortification of milk with iron. Recent food consumption surveys have shown iron to be an element likely to be deficient in many important population groups.

2. Whey utilization. Anti-pollution regulations dictate that improvements be made in utilizing the 22 billion pounds of liquid whey produced annually in the United States. Our research in this area is being intensified.

3. Nitrosamine research. Fears have been expressed recently that carcinogenic nitrosamines may conceivably be formed either in some food products or from food precursors after ingestion of some food combinations. Extensive research is needed to explore this field and we have put a team of workers on it.

4. Potato glycoalkaloids. The variety of potato formerly designated as Lenape was found to have undesirably large quantities of alkaloids. We have initiated research to improve methodology for analyzing for potato glycoalkaloids.

5. Eutrophication. Our research on animal fats will emphasize a search for improved surface active agents and lime-soap dispersants that may be effective in the presence of little or no phosphate and related builders.

These are but a few of our areas of current emphasis.

I should mention one further and more drastic program change envisioned at the Eastern Division.

In 1971 our tobacco program will be moved from here to the Richard B. Russell Agricultural Research Center in Athens, Ga. This involves the work of about 20 people. The tobacco program will continue there with its emphasis on health-related aspects and with the objective of development of safer cigarettes.

Today's Program

Finally, we come to our program of the day.

Wastes are a timely topic and an important one. Before I turn the program back to your chairman, I would like to call your attention to two publications on wastes issued recently by the Agricultural Research Service. One of these is called Agriculture and the Environment, a rather simply worded and general statement of selected problems and some approaches being made to their solution. A second leaflet is called Environmental Quality, A List of Available Information Materials. Both of these were issued in August 1970, and you may be interested in looking at or obtaining copies of them.

UTILIZATION OF WASTES FROM CHEESE MANUFACTURE

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At the outset I wish to identify where the dairy industry contributes to the problem of environmental pollution. A chart just released by the Economic Research Service (figure 1) helps to do this. According to this chart, showing changes in dairy product sales per capita for the past decade, dairy foods containing fat have in general been losing favor with consumers, while the low-fat and nonfat products have been gaining. An exception to this trend, however, is cheese, sales of which have been steadily rising. I have taken the liberty of marking cheese on the chart as our problem area, since it is the increased consumption of cheese that is responsible for the large excesses of whey which must be disposed of in some fashion. Disposition of this cheese whey in a form that will not add to pollution is the subject of this talk.

What does the dairy industry's annual contribution to environmental pollution amount to? The magnitude of dairy wastes is summarized in table 1. It is evident that by far the most serious source of pollution by the dairy

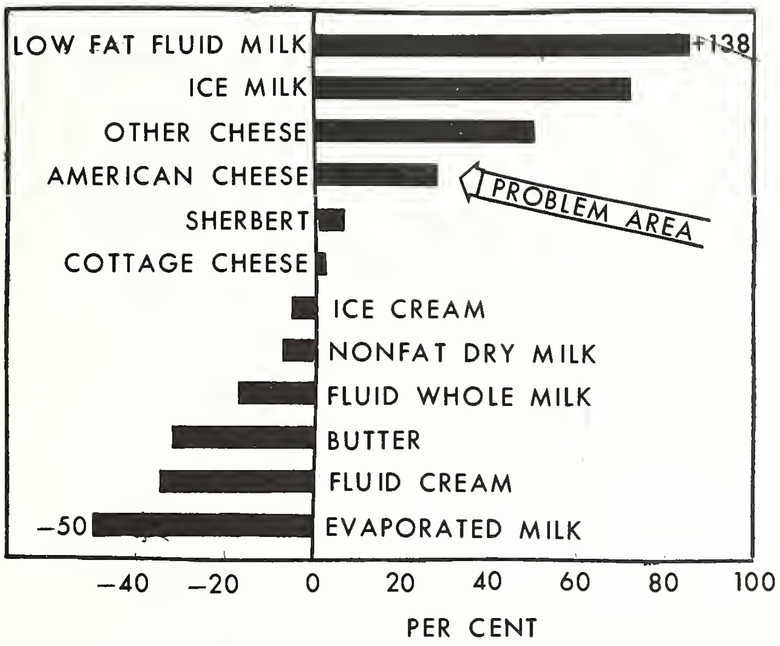

Figure 1.--Changes in dairy product sales per capita, 1959 to 1969. (Source: Dairy Situation, USDA, ERS DS-333, November 1970)

TABLE 1.--Dairy industry's annual contribution to environmental pollution

Polluting source	Amount	Percent solids
Wash water	31.7 billion gallons	0.01
Cheese whey	3.5 " "	4.0
Condenser water	16.0 " "	0.02
Spray-drier fines	60 million pounds	96.5

industry comes from cheese whey. Approximately 3.5 billion gallons of whey, containing 4.0 percent solids, are produced each year. It should be emphasized that this is potential pollution. One-third of the cheese whey now being produced is actually being used for food and feed. None of the spray-drier fines are being recovered, and most of the wash water and condenser water is going down sewers or into rivers.

The problem of environmental pollution by cheese whey is growing even faster than anticipated. Figure 2 is a graph showing the projected future cheese whey production based on a study made by experts a few years ago. Already, in 1970, actual whey production exceeded the estimate shown here by about 10 billion pounds.

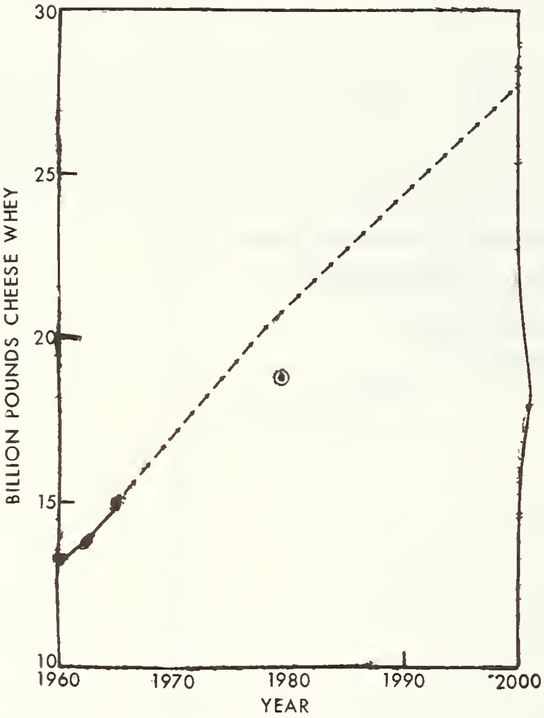

Figure 2.--Projected future cheese whey production.

Whey is presently being utilized to the extent of about 7 billion pounds a year. This is the amount that is dried (by roller drying and spray drying) and made into lactose. A small amount of whey is made into protein concentrates. The rest of the production, 14 billion pounds, or twice the amount that is used, is dumped into rivers, lakes, abandoned quarries, old mines, or any other place where it can be discarded without too much complaint.

Since whey contains over 90 percent water, reasonable plans for its utilization usually start with removal of the water. One method of doing this is by roller drying, which is represented in figure 3. This is accomplished by simply applying a film of liquid whey onto the surface of hot drums.

You might envision this as a continuous pancake griddle, with the whey applied to the hot drums and dried at atmospheric pressure. When the water is boiled off, the whey is scraped off the drums onto conveyors for subsequent grinding and bagging prior to utilization or disposal.

Dehydration of whey can also be effected by spray drying, as shown in figure 4. Spray drying requires much more complex equipment, including a large cone-shaped chamber filled with hot air into which the whey concentrate is sprayed as a fine mist. The whey is dried almost instantaneously by this method and then removed from the bottom of the chamber for bagging.

A third of the whey now being produced is cottage cheese whey. This cannot be dried directly by either the roller or conventional spray process because of its high acid content. One of our innovations is foam-spray drying, a process that can be used to dry all types of whey, including that from cottage cheese. The unique characteristic of this foam-spray process, which is shown in figure 5, is that compressed gas is injected into the concentrate as it is being pumped to the drying chamber where it is atomized into fine droplets. Compressed air causes the concentrate to foam in the drier. This makes the particles in the drier bigger, so that the heat is more readily transmitted through their mass, and they dry much more quickly.

When either sweet whey or cottage cheese whey is dried, regardless of the method of drying, it produces a powder with the composition shown in table 2. Both types are predominantly lactose, with around 12 percent protein and a fair amount of ash. The whey from cottage cheese, which is made by either natural or artificial acidification of skim milk, contains a relatively high amount of lactic acid, which makes it difficult to dry by conventional processes.

TABLE 2.--Composition of dried whey powder (percent)

Component	Sweet whey	Cottage cheese whey
Fat	1.2	--
Protein	13.5	11.8
Lactose	74.5	69.7
Ash	8.4	7.8
Lactic acid	2.4	10.7

Whole whey sells at about 9 cents a pound for food use, depending on the quantity. Sold for animal feed, it brings 4 to 5 cents a pound. Drying the material costs about 3-1/2 cents a pound, leaving virtually no profit margin and providing no incentive for processors to invest large amounts of

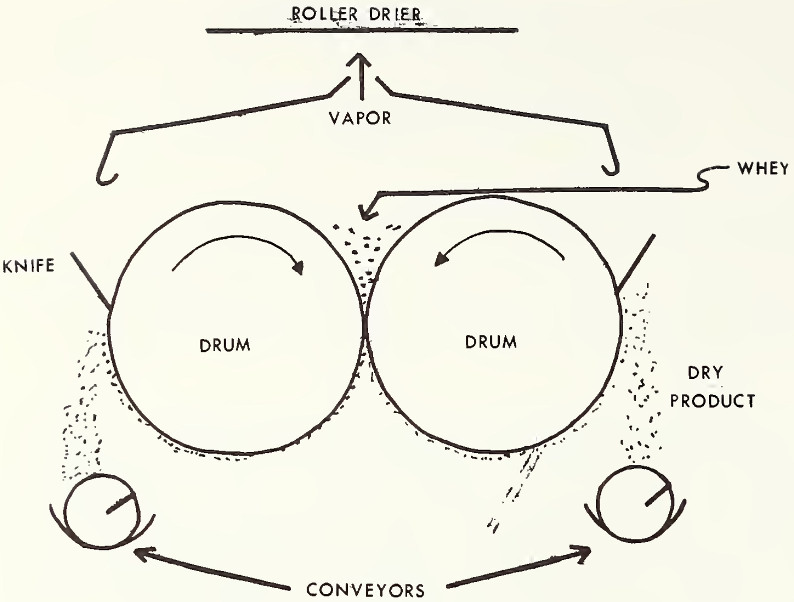

Figure 3.--Roller drying.

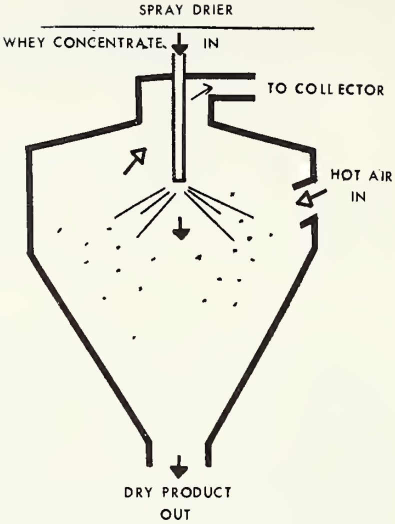

Figure 4.--Spray drying.

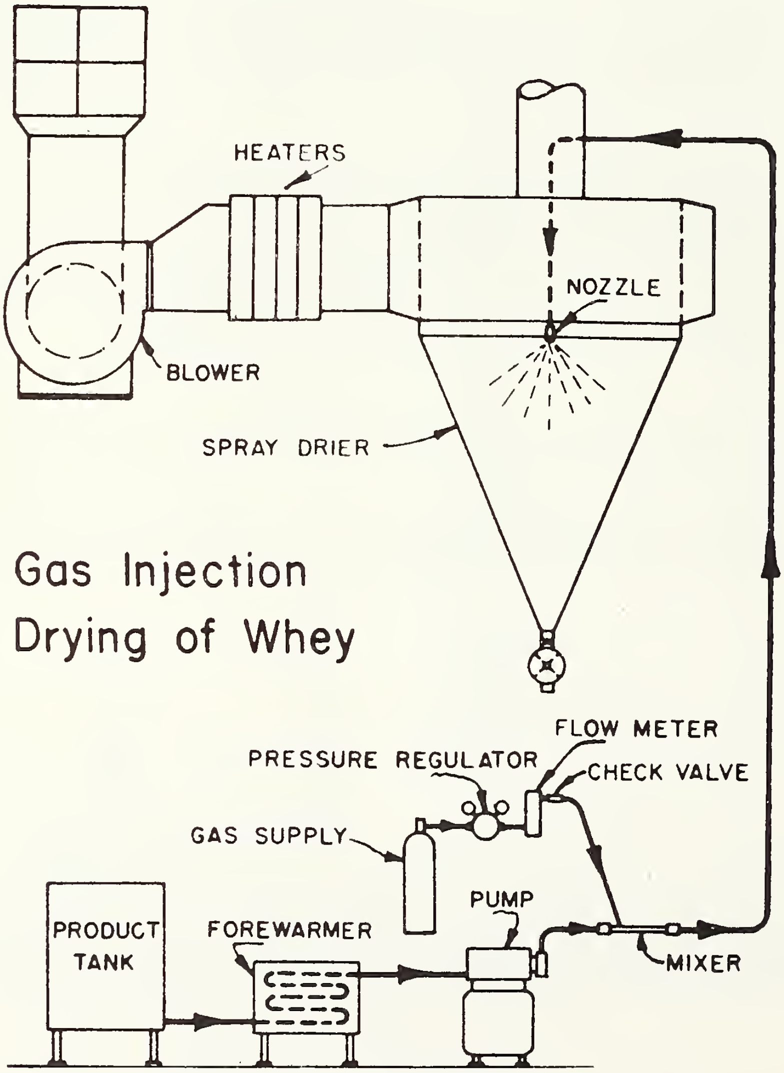

Figure 5.--Gas injection drying.

money for efficient drying machinery. Spray driers, for example, represent multimillion dollar investments. But if the whey were to be fractionated, its more valuable components in a relatively pure state should be of far greater worth than the whole whey. The protein, for example, might be worth as much as a dollar a pound, and the lactose should bring anywhere from 9 to 27 cents a pound depending upon its grade. So whey fractionation promises to increase its overall value to perhaps as much as 26 or 27 cents a pound or even more.

There are several procedures capable of fractionating whey, such as reverse osmosis, ultrafiltration, gel filtration, electrodialysis, and electrophoresis.

Of these methods, perhaps there is most interest right now in reverse osmosis, which is represented in figure 6. This process uses a two-compartment chamber divided by a membrane permeable only to water. The whey is placed in one compartment and water in the other, and pressure is applied to the whey in excess of the osmotic pressure that would normally force the water through the membrane to dilute the whey. This reverse pressure forces the water in the whey in the opposite direction, thus concentrating the whey. We are doing a considerable amount of research in this Division on reverse osmosis, especially as it applies to whey concentration.

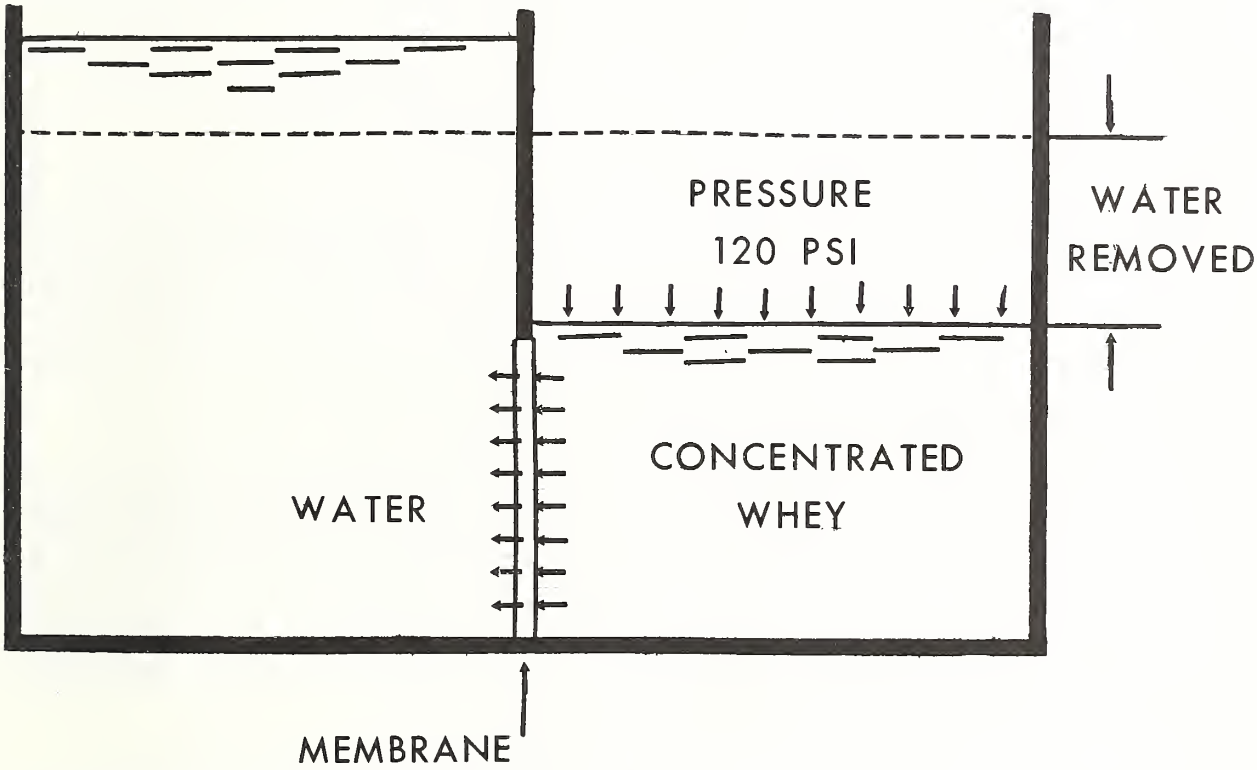

Figure 6.--Reverse osmosis.

Ultrafiltration is essentially a refinement of the reverse osmosis process, in which a coarser membrane is used, allowing the salts and sugars to pass through as well as the water. Thus ultrafiltration is capable of producing a high-protein whey.

Now what are the potential outlets for whole whey and whey fractions in the food industry? It is difficult to find outlets for whey in the food chain without displacing some other food that has an established priority. Some special foods in which the whey may be used are as follows: baking blends, poor man's foods, sherbets, cake mixes, juice drinks, creams (dips and chips), cheese (Ricotta), spreads, candy, beverages (carbonated), acidulants, and noodles.

For over 30 years our laboratory has been concerned with finding new food outlets for whey. Our early work has been with whole whey, and has concentrated on cottage cheese whey which, because of its high acidity, is the hardest type to find uses for. Our research has shown that cottage cheese whey tightens the grain in white and rye bread; improves the nutritional value of fruit-ice lollipops; gives a darker, richer color to devil's food cake mix; and improves the flavor of citrus pie-filling and pudding mixes.

In addition to these direct uses for whole whey, we have also tried to formulate new types of foods using spray-dried whey. We have concentrated on relatively inexpensive foods that might be used in feeding programs for developing nations. One of the things we have done is to combine liquid cheese whey with soy flour. The two are mixed, pasteurized, homogenized, condensed, and then spray dried. This gives a better product than blending dried whey with soy flour, as shown in table 3.

It was found that the condensing step, which is essentially a steam-deodorizing operation, and the spray drying, eliminated essentially half of the soy flour. Now, two years after the disclosure of this work, a similar product has appeared on the market made with a soy concentrate instead of soy flour. We have discontinued most work along these lines, since these whey-soy blends are essentially competitors for low-fat dry milk in practically all food operations.

More recently we have moved away from the use of soy in these blends and replaced it with butteroil, a dairy product of which we have a surplus.

We have combined butterfat and whey together to make an entirely new type of spread. To make this product we simply mix together whey or concentrated whey and butteroil or cream. We homogenize, pasteurize, and concentrate the mixture. When the solids content rises to a desirable consistency, a delicious spread somewhat similar to cream cheese is produced. A typical composition for this spread is as follows: butterfat 37.5 percent, TABLE 3.--Comparison of soy flavor in blends of soy flour with whey and nonfat dried milk

Composition	No. of judges rating least soy flavor	Average rating of soy flavor (full soy flavor: 18)	t-test
2/3 Whey 1/3 High-fat soy flour			
Spray dried	14	9.8	2.52
Dry blend	3	12.6	(2% level of signif.)
1/3 Soy flour 1/3 Nonfat dried milk 1/3 Sweet whey			
Spray dried	17	9.4	4.05
Dry blend	3	13.0	(1% level of signif.)

whey solids 37.5 percent, water 25.0 percent. This is a low-fat spread with excellent spreading properties over a wide range of temperatures. Its only limitation is that it does not melt, making it unsuitable for use in hot foods. The product is no competitor for butter. It is completely unlike butter. It is a unique spread, and we hope that eventually it will find some use in the food market.

In addition to whole whey, we have tried to find new food uses for the fractions obtained by such processes as reverse osmosis. In one experiment we used reverse osmosis as an ultrafilter. We passed the whey through a reverse osmosis apparatus using a coarse membrane to produce a concentrate. By this means we increased the total solids from 7 percent to 20 percent and the protein from 12 percent to 35 percent. The lactose was correspondingly reduced from 72 percent to 52 percent and the ash from 10 percent to 6 percent.

For further concentration, we followed the ultrafiltration with gel filtration, then pasteurized, condensed, and dried the material. This results in a whey powder of 2.94 percent moisture whose protein has been increased to over 69 percent and whose lactose and ash have been reduced to about 19 percent and 2 percent respectively. We think this product should be worth about 70 cents a pound, if pure whey protein is priced at a dollar a pound.

We have developed still another whey powder containing almost 80 percent protein. It is called EUPRO-80. It is made from cottage cheese whey by lowering the pH to 2.5 and adding a polyphosphate, then collecting the precipitated protein with a centrifuge. This gives a protein sludge whose pH is restored to 6.8 to dissociate the phosphate-protein complex, and then put through gel filtration. We evaporate and spray dry the protein eluate and the resulting powder contains 78.67 percent total protein and a negligible amount of lactose (2.93 percent). As we now make it, EUPRO-80 has a rather high ash content of nearly 14 percent, but we feel we have a way of reducing this.

In view of the present interest in nutrition, we are concerned about the extent to which these various processes affect the food value of whey. Table 4 traces the effects of the various concentrating and drying processes on the amino acid lysine. The table shows not only how much lysine is present in the processed products, but how much of this is actually nutritionally available. The figures show that roller drying destroys lysine to a large extent.

TABLE 4.--Effects of various method of whey processing on total and available lysine

Process	Lysine		
	Total	Available	
	G./100 g. protein	G./100 g. protein	Percent
Roller drying	5.25	1.90	36.2
Spray drying	6.90	3.41	49.4
Electrodialysis and spray drying	6.64	5.11	77.0
Reverse osmosis and spray drying	9.40	6.37	67.8
Gel filtration and spray drying	10.91	8.58	80.4
Reverse osmosis, gel filtration, and spray drying	9.43	7.52	79.8
De Laval process	8.25	3.79	45.9

Spray drying is a little better, and the whey that is put through electrodialysis before spray drying is still further improved. The three processes we have developed, namely, reverse osmosis, gel filtration, and a combination of the two, show an excellent preservation of lysine, bringing the total lysine up to about 9 to 10 percent, with anywhere from 67 to 80 percent of it nutritionally available. The De Laval process, which only recently has gone into commercial operation, preserves a good amount of the total lysine, but less than half of it is nutritionally available.

In spite of the progress made in the great amount of research done to date on whey, there are still two serious unresolved nutrition problems. The first one is lactose intolerance. Large segments of the world's population, including a number of racial groups such as the blacks and Orientals in the United States and considerable numbers of African and Indian people, are lacking in the enzyme lactase which breaks down lactose in the digestion process and makes it acceptable to the system. Such people cannot take large quantities of any dairy products containing lactose.

The other unresolved nutrition problem is salt intolerance. Many infants are incapable of digesting much salt. Since cow's milk contains much more salt than mother's milk, many nutritionists feel that the widespread feeding of milk and dairy products to infants and young children is a contributor to the widespread hypertension in our present population. There is far less than unanimous opinion on this point, but it is a serious consideration for any who are doing research on dairy products such as whey.

I hope this brief survey has given you some insight into the problems of whey utilization.

ALLEVIATION OF POLLUTION BY POTATO STARCH FACTORY WASTES--A PROGRESS REPORT

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Agricultural Research Service, USDA

Although potato starch manufacture uses only about 6.4 percent of the potatoes processed, it produces 15 percent of the pollution from potato processing, since only starch is retained and all other constituents are wasted. Potato starch manufacture is, in itself, a salvage or disposal operation and must operate with culls of culls. It provides a market (of sorts) for 415,000 tons of very low grade material annually. Its only product is in a highly competitive market and there is very little room for additional cost factors.

Manufacturers cannot afford, under the present market structure, to abate pollution by conventional biological oxidation. In starch manufacture, all solubles, 27 percent of the dry weight of potatoes, have been dumped into the nearest stream. This is the waste from which we must recover enough values to hopefully pay the cost of recovery. After suitable water conservation practices, these compounds are available in the plant at about 2 percent solids. Continuing earlier research, we have applied ion exchange to recover some of these materials Less than 180 parts per million (p.p.m.) of proteins in the liquid can be tolerated in the ion exchange column feed, while typical protein water contains 1,500-4,000 p.p.m. Precipitation by steam injection heating at 220° F. was found to give good yields of easily filtered precipitates, without scaling of the heating surfaces encountered with tubes. The high turbulence incident to steam injection promotes easy filterability. At the normal pH of 5.8, 75 percent of the protein is recovered, while at pH 4.2 and below, recovery is 95 percent.

A strong-acid cation exchanger in the hydrogen cycle removes cations (largely K) and free amino compounds, using two columns, run to K breakthrough in the first. The first is eluted by H_2SO_4 to recover potassium salts and the second by NH_4OH to recover amino compounds. Effluent from the second column is passed through a weak-base anion exchanger, removing half of the remaining solids, leaving only sugars in the effluent.

The amino acid mixture and protein are rich in essential amino acids, but low in methionine. The organic acids are largely citric and malic. A small demonstration plant at a starch factory was originally planned to show the process and accumulate product for evaluation. Before this, after process details were sufficiently known, cost evaluations of all parts of the process were made, as well as for the alternative, conventional biological oxidation of the wastes. It immediately became apparent that additional lower-cost options than the ion-exchange process should be considered. Estimates were then made for several, of which the only economically viable alternative, especially if feed markets are considered, was concentration of the entire effluent. Prospects of selling the other products at a loss that would not exceed the cost of biological oxidation appear rather remote.

The residual potato pulp from starch recovery is dried at some plants, but it has a relatively low feed value and is difficult to market even at cost. When a concentrate of starch plant protein water solubles is mixed with it in the proportions in which they would be produced, a value for cattle feeding of at least 20 percent above corn was estimated, or $58 per ton. On this basis the concentrate alone should be worth $73.50 per ton at 55 percent solids, or 3.67 cents per pound. This is above the break-even price.

Since the protein of potatoes is of excellent quality, feeding tests will also be made on nonruminants and poultry. In Europe, recovered potato protein is considered superior to soy protein for swine feeding. At 75 percent protein, it brings a price slightly below herring meal for feeding to baby pigs. The Federal Bureau of Agricultural Chemistry in Vienna reported that potato protein has the same nutritional value for hogs as does meat, and has an advantage over fish meal in that its bland nature makes it practical for use up to time of slaughter.

Amounts of condensed protein water solubles available in Maine could easily be absorbed by the poultry industry in that State if benefits could be shown to justify its inclusion. Efforts will be made in this direction.

CONTROL OF ENVIRONMENTAL POLLUTION BY HIDE PROCESSORS AND LEATHER MANUFACTURERS

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The utilization of animal hides and their conversion to leather results in the production and discharge to the environment of a large volume and variety of pollutants. A partial list includes: sodium chloride, calcium hydroxide (solution and solids), inorganic sulfur compounds, nitrogenous bases, inorganic acids, chromium salts, phenolic tannins, fats, proteins, dyes, and complex organic polymers.

Before hides can be converted into leather the hair must be removed. In the past, the hair constituted a valuable byproduct. But loss of markets for it and the high cost of labor to remove and process it are forcing more tanners to simply dissolve the hair by using a high level of sulfides. Since each hide contains about 4 pounds of hair, this makes hide-processing wastes exceptionally high in solids and biological oxygen demand (BOD).

The pretanning operations are called beaming, and that part of the tannery complex devoted to these operations is called the beamhouse. The steps that hides undergo in preparation for tanning and the waste produced by each step are outlined below:

Salt-Cured Hides
Wash Wheels → Wash Water
Soak Vats → Soak Water
Lime Vats → Lime Liquors
Rinse Vats → Rinse Water
Unhairing → Hair Wash, Hair Wash Water
Fleshing → Fleshings, Fleshing Water
Bating → Bate Water
Hides to Tanning

Equalization Basin

The wastes discharged by a tannery fluctuate widely in rate and quality, so that it is unsatisfactory to treat them on a continuous, as received, basis. One of the first steps in the treatment process should be an equalization of the wastes discharged relative to both flow and quality. If the wastes are diverted to an equalization tank, the maximum concentration of their various constituents as they come from the tank are estimated to be as follows (in milligrams per liter)(1):

Calcium	1,700
Sulfide	190
Total solids	19,500
Suspended solids	4,320
Alkalinity	1,240
Chromium	460
5-Day, 20° C. BOD	2,100

Special designs may permit the equalizing function to be combined with carbonation, primary sedimentation and other processes. Which functions should be combined will be decided during the final design when the specific equipment to be used is selected.

A 24-hour survey was made of a typical tannery that processes 2,500 hides per day. The results indicated that the equalized load discharged in the effluent would be as follows:

Flow (gal. /day)	801,520
pH range	6.1 - 11.7
Alkalinity to pH 8.3 as $CaCO_3$ (lb. /day)	2,620
5-Day 20° C. BOD (lb. /day)	7,180
Settleable solids (gal. /day)	70,810
Total solids (lb. /day)	47,150
Total volatile solids (lb. /day)	14,060
Suspended solids (lb. /day)	11,260
Volatile suspended solids (lb. /day)	8,480
Calcium as $CaCO_3$ (lb. /day)	5,960

Much of the above load consists of chemicals added at the tannery during processing. However, the hides entering a tannery bring with them appreciable quantities of waste materials--mainly salt and nonleathermaking proteins--that eventually require disposal.

Salt

In the curing of hides and skins there is at present no economically feasible method of disposing of the salt without pollution. Brine curing, practiced by about 60 percent of the industry, removes 1.5 gallons of water from each hide as brine and adds to the total volume. Green salting, in which rock salt is spread on the flesh and the hides stored in packs for 30 days, causes a less apparent problem, but the same dehydration takes place with the brine draining off. The United States production of 36 million hides produces for disposal 140 million pounds of salt, as an aqueous solution. Salt-cured hides contain 12 to 14 percent salt when they arrive at a tannery. This salt is removed in preparing hides for tanning. On the basis of current utilization of 22 million hides, United States tanners add 137 million pounds of salt to the effluent. Thus the total of 349 million pounds of salt used in the curing and processing of hides ends up as a pollutant.

Proteins

Leathermaking also removes appreciable quantities of proteinaceous materials from hides. These amount to about 450 million pounds as fleshings and trimmings per year. The best of the trimmings are used for gelatin and glue when near a factory, but glue factories have been closing at an accelerating rate in recent years. The fleshings and many of the trimmings are now hauled to dumps or hydrolyzed and put down the sewer. In addition, chrome shavings equal about 50 million pounds. They are intractable, potentially toxic, and have been mainly disposed of as land fill.

Some 144 million pounds of hair are removed from hides and skins each year. About half of this is dissolved by using a high amount of sodium sulfide in the unhairing process. Both the decomposed keratin and the excess sodium sulfide are objectionable. The sulfide can be converted through oxidation to a form no longer exerting a high BOD. Nevertheless, this constitutes an expense and the converted form contributes to the soluble solids of the effluent. Suitable recovery of the protein would yield a feed additive which, at 5 cents a pound, would be worth $3.5 million.

Industry Programs

The tanning industry is reducing its pollution load by using lagoons, settling basins and aeration beds before the effluent is discharged to streams or municipal sewage systems. These expediencies are inadequate to meet current standards for pure water. At least two tannery pilot plant studies have been completed in cooperation with the Federal Water Quality Administration. One tannery is building a $1.5 million purification plant that upgrades the water to meet present stream standards. Estimates indicate that such a system will add about 1.5 cents per square foot to the cost of leather. The question still remains whether this costly system will meet the water-quality standards that will be required by 1985.

Proposed Research

Since the cost of effluent purification is proportional to the load, a logical approach to pollution abatement would be to develop procedures that reduce the pollution load either through recycling, elimination from process, or conversion to useful byproducts. To meet these latter criteria, our research approach is directed along the following areas:

1. To develop processes for preserving hides without the need for salt. A temporary preservative that would keep hides from spoiling for a week would enable tanners to process a bulk of their production as fresh hides. The $1.50 saved per hide is attractive.

2. Recovery of products from wastes.

(a) Fleshings and trimmings contain protein and fats. These were once recovered at the glue works as soap stock and glue. The possibility of converting the protein to derivatives suitable as chemical intermediates may be more economic now since the cost of disposal would become a cost credit.

(b) Recovery of hair and conversion to either animal feed or to chemical intermediates also has a better economic image than it once had.

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A PROFITABLE APPROACH TO ABATING POLLUTION: CONTRIBUTIONS OF THE SOUTHERN MARKETING AND NUTRITION RESEARCH DIVISION

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The results of research to abate pollution obviously are more likely to be accepted by industry if they offer economic as well as environmental advantages. Therefore, Southern Marketing and Nutrition Research Division (SMNRD) research on pollution is directed to this dual goal.

Contributions of Previous Research

Until recently, of course, the reduction of pollution was not emphasized in research at SMNRD. Our primary objective was increased utilization of agricultural commodities. However, retrospective review shows that our previous research frequently also achieved the important dividend of reduced pollution.

An outstanding example of this dual accomplishment is frozen orange concentrate, which was developed at our Winter Haven Laboratory in Florida in cooperation with the Florida Citrus Commission. This development had an important economic effect: the market for frozen orange concentrate is now a million dollars a day at the consumer level. But the use of the concentrate instead of huge quantities of fresh fruit has also made a major contribution to reducing pollution: the residue, instead of generating garbage throughout the country, is now kept at processing plants, where most of it is dried for use as feed; fuel requirements for shipping are greatly reduced; and the packaging materials to be discarded weigh only a fraction as much as the residue from a comparable amount of fresh fruit and present a far less serious disposal problem.

Another contribution from our early research concerned utilization of byproducts from the commercial production of sweetpotato starch. Processes were developed for recovering two useful products from the fruit water: protein and a medium for the growth of Torula yeast. By these processes, the fruit water was purified sufficiently to be discharged into natural waterways.

Another byproduct that created disposal problems was the soapstock produced during the refining of cottonseed oil. Scientists at SMNRD developed a process for producing mixed methyl esters directly from acidulated soapstock, methanol, and a special catalyst. Used commercially for many years to produce feed additives, the process is also applicable to soapstocks from soybean and corn oil.

Contributions of Present Research

Within the last several years, SMNRD has placed increased emphasis on research to reduce pollution. A primary or major objective of many new lines of work is the reduction of pollution arising from the processing of agricultural materials. At the same time, new or improved products or processes are developed in the research.

Citrus

Scientists at our Winter Haven Laboratory have developed a technique for recovering water-soluble aroma solutions and distilled oil from one of the troublesome effluents discharged in citrus processing. The recovered solutions and oil greatly enhance the flavor of frozen, canned, instant, and other citrus products. Although the process has not yet been developed commercially, many processors in Florida have shown keen interest in it.

Another contribution from recent research is the development of comminuted whole citrus products by researchers at our laboratory in Weslaco, Texas. Since 85 to 90 percent of the whole fruit is converted into puree, obviously the problem of waste disposal is greatly diminished. The puree can be diluted for citrus drinks that have acceptable flavor, color, and other characteristics. It can also be used in syrups, baked goods, and other food items.

Converting citrus wastes to dried feed and molasses now not only provides necessary disposal of the material but also brings a gross return of $27 million annually in Florida alone. But air pollution from particulate matter in the stack gases discharged from citrus feed mills has become a major problem. In contract research to USDA, scientists at Fiske-Gay Associates, Inc., of Orlando, Florida, are demonstrating different ways to adequately regulate emissions. This study will permit plants of all sizes to achieve control at a cost they can absorb--a major contribution to reducing pollution from this source.

Other Fruits and Vegetables

Our Weslaco Laboratory has devised a process to peel tomatoes by spraying or immersing them in liquid nitrogen, liquid air, or Freon just long enough to freeze the skin but not the flesh. When the tomatoes thaw, the skin slips off readily if it is broken or cut. In comparison with commercial methods, the new freeze-peeling process results in less pollution, yields a product with better color and greater firmness, cuts losses in half, and should reduce labor costs. Many canners throughout the country have expressed interest in the process.

A pure culture fermentation process for pickling cucumbers and other vegetables was developed by our Food Fermentation Laboratory at Raleigh in cooperation with the North Carolina and Michigan Agricultural Experiment Stations and the National Pickle Packers Association (now Pickle Packers International, Inc.). It should present fewer disposal problems with salt and acid wastes than the conventional brining process. And, at the same time, it will enable processors to improve quality, tailor flavor characteristics, offer new products, and reduce costs. The process has also been applied to tomatoes, peppers, carrots, and other vegetables as well as to Manzanillo olives.

A new peeling process developed at the Southern Division in cooperation with the Western Division will greatly reduce the effluent from conventional caustic peeling of sweetpotatoes. It is an adaptation of the Western Division's process for white potatoes. The new systems are called "dry" caustic peeling because most of the peel and tissue is removed mechanically without the use of water.

Researchers at our Winter Haven Laboratory have devised several processes for obtaining flavorful celery oil from parts of the fresh celery plant now discarded as waste. In addition to improving the flavor of processed celery products, the oil should find widespread use as a seasoning for other foods.

Cotton

Although I have discussed primarily fruits and vegetables so far, a major part of the research at the Southern Division is on cotton. Since textile processing produces a considerable amount of stream and air pollution, our research on cotton has offered an opportunity to help solve these problems.

Permanent sizing has been developed to eliminate the usual desizing step that causes so much stream pollution. It consists of polymers such as polyurethanes or polyacrylates applied to yarn before weaving. This permanent sizing confers another advantage: a lower concentration of agents can be used to produce durable-press fabrics with improved strength and abrasion resistance. At present, the process is being evaluated by several textile mills.

In other research, a process using liquid ammonia has been devised to replace conventional mercerization using sodium hydroxide. The ammonia can be reclaimed, and the organic material removed from the fabric can also be collected and utilized.

Another approach is the use of nonaqueous agents throughout the total system of cotton finishing. Processes for the preparatory steps are already available either commercially or on a laboratory scale. Now a method is being studied at the Southern Division for applying durable-press finishes to cotton fabric from organic solvents. Development of such a method could provide the last link needed to permit industrial use of a completely nonaqueous finishing system.

Potential Contributions of Future Research

Now I'll briefly mention some types of research that we plan for the future. One approach is to reuse materials in the same processing system or to use them for another purpose. A second is to remove potential pollutants from agricultural commodities or byproducts before they are used. And a third is to use agricultural commodities to remove pollutants from other materials. In particular, much of our future research on pollution will be directed toward solving problems connected with typical agricultural residues in the South: canning wastes such as peels, pits, seeds, pulp, and liquid extracts from fruits and vegetables; peanut shells; rice and cottonseed hulls; bagasse; sweet sorghum wastes; and spent liquors from the production of protein isolates.

EFFECT OF PROCESSING CONDITIONS ON FRUIT AND VEGETABLE WASTE EFFLUENTS

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A primary responsibility of our department is to carry out research that may benefit New York's fruit and vegetable processing industry. Traditionally, this has meant studies on food flavor, texture, and color; on spoilage and other microbiological problems; and on various aspects of food engineering. The current concern over environmental quality has caused us to become involved in a less traditional area of food research; namely, investigations on processing wastes. My comments today represent a progress report on one of our newly created projects, one that is concerned with the effluents that are generated when fruits and vegetables are canned, frozen, or fermented.

The Situation

It appears to us that, generally, fruit and vegetable waste waters do not present special treatment problems. In other words, most of the organic compounds present in these wastes are readily biodegradable. There are, of course, always exceptions--for example:

1. Certain plant pigments such as betanin, which are responsible for the red color of beets, resist breakdown and, therefore, may still be evident after the waste water has been treated.

2. Some food industries have strong brines that may be difficult to treat. The production of sauerkraut results in a brine with about 2 1/4 percent sodium chloride. Salt stock cucumbers may present an even greater problem since their brines may contain as much as 15 percent salt.

3. The pH of some waste waters may be unfavorable for biological treatment. Sauerkraut brines, for example, have a pH of about 3.5 and a titratable acidity, expressed as lactic acid, of 2 percent or more. At the other extreme, certain effluents may be strongly alkaline due to the presence of lye peeling liquors or alkaline cleaning compounds.

The main problem associated with fruit and vegetable processing is that the volumes of waste water are large and the strength usually is high.

In the canning industry, two gallons or more of water, used primarily for washing, blanching, fluming and cooling, may be discharged for each No. 303 (one-pound) can that is packed. The overall effect is that a given factory may have to discard over one million gallons of waste water per day.

Some of our own studies on the strength of food processing wastes have revealed 5-day biochemical oxygen demand (BOD) values of 19, 000 parts per million (p. p. m.) for apple effluents, 6, 500 for beets and 2, 200 for snap beans. A sample of sauerkraut waste water set the record with a BOD of 41, 000! In contrast to these figures, domestic sewage has a BOD of only 200 to 300 p. p. m.

Research Approach

We have felt that as food scientists we could make our biggest contribution by studying the wastes before they were discharged from the factory. It was our belief that in-plant studies might point to changes in processing methods that would reduce the amount of waste being generated. It also was thought that this approach might reveal certain waste streams that should be segregated for special treatment.

We were optimistic that this approach would be fruitful since our observations of commercial processing lines over a number of years suggested that many unit operations and processing systems had been designed with little concern for the quantities of waste water that they produced. (In our recent carefree past, pollution seemed to be less of a problem.)

Our research plan called for repeated surveys of numerous factories processing a given fruit or vegetable. The sources of waste water were to be identified and then flow measurements were to be made. Samples of effluent and product from the different unit operations were to be collected for laboratory analyses. The water was to be analyzed for such things as BOD, total and suspended solids, volatile solids, and pH. The food samples were to be cultured for total microbial counts as a means of evaluating processing-line sanitation. This was considered important since we did not wish to recommend water-saving measures that might sacrifice product quality.

Survey Results - RSP Cherries

We got our feet wet this past season--and we mean this literally--studying factories that were processing red sour pitted cherries. Most of the work was done at four plants where a total of 22 surveys were carried out.

We began with cherries because the process appeared to be relatively simple and, thus, we anticipated fewer difficulties in making the necessary flow measurements and sample collections. Although this may have been true, inaccessible sampling sites still were found to be a major problem. In none of the four factories, for example, was it possible to measure and sample the final effluent streams that contained the pooled waste water from all of the different sources. Because of this, we could not check the accuracy of our individual waste-stream measurements--a check which would have assured us that we had not missed a source of waste water.

The main effluent streams were found to originate from the soak tanks, the sprays used for rinsing, and the flumes that conveyed the pits (Table 1). Fresh water was used in the sprays and pit flumes while the soak tanks represented a semi-closed system in which water was recirculated through the tanks, a cooling bath, and various flumes. The 1,590 gallons discharged per hour from the soak tanks at Plant No. 2 represented the discharge-make-up rate. In addition to this, the system was periodically drained and refilled with fresh water, which means that the total effluent volume from this source was higher than shown in Table 1, as was the total BOD per ton of cherries. The magnitude of this underestimation is not known because figures were not available on the volume of water in the different soak systems.

TABLE 1.--Waste water sources - Plant No. 2

Unit operation	Waste Water		
	Amount (gal./hr.)	BOD	
		Total (p.p.m.)	Lb./ton of cherries
Soak tank	1590	136	0.17
Spray rinse	1580	334	.42
Pit flume	3110	1070	2.8

Measurements of the soak-water waste streams were made at only two of the factories because at the others sampling at this point was physically impossible. The results (Table 2) showed a significant difference between the factories in the amount of water consumed at this processing stage. It can be seen that the waste water from Plant No. 1 had a BOD per ton of fruit 40 times of that from Plant No. 2. Part of this difference probably

TABLE 2.--Comparison of soak tank effluents

Plant	Amount (gal./hr.)	BOD		Microbial count (microorg./ml.)
		Total (p.p.m.)	Per ton of cherries	
1	2,910	1230	6.4	120×10^4
2	1,590	136	0.17	51×10^4

can be attributed to size of operation; Factory No. 2 was considerably larger and, therefore, would be expected to be able to use water more efficiently. Still, the data are somewhat perplexing in that Plant No. 1 produced an effluent with a higher BOD and microbial load, although its water make-up rate was greater and it drained its soak system daily as compared to a weekly draining at Plant No. 2. The latter factory had an in-plant chlorination system which No. 1 lacked, however, and it is possible that this accounted for some of the differences. (It appears that we'll have to take another look next summer.)

Microbial counts were made on both the recirculated soak water and on fruit collected from the soak tanks in order to assess the effect of water quality on the quality of the fruit. Marked differences in microbial numbers were found from survey to survey (Table 3). These differences are thought to reflect the length of time that the water had recirculated, that is, the number of days since the system had last been drained. Although the counts on the fruit did not parallel those of the water as closely as might have been expected, some relationships were noted. For example, it can be seen that the most heavily contaminated cherries, collected on July 30, were taken from soak water that contained a count of almost two million organisms per ml.

Our conclusions regarding the soak water systems were that there may be little basis for the conditions under which they usually were operated--in particular, the water make-up rates, and the frequency of draining the systems. It would appear, therefore, that here was an operation where economies in waste-water production could be effected.

Another source of waste water at the four processing plants were the flumes used to transport cherry pits (Table 4). A surprising finding was that all of the processors used fresh, potable water for this operation. It would seem that here was a second area where the volume of waste water could be reduced significantly, either by recirculation of this water or by the use of some nonaqueous conveying system.

TABLE 3.--Water versus fruit quality - Plant No. 2

Survey Date (1970)	Recirculated water		Cherries
	BOD (p.p.m.)	Organisms/ml. (x 10^{-3})	Organisms/g. (x 10^{-3})
7-22	-	21	5
7-27	229	120	41
7-28	54	550	9
7-29	-	530	12
7-30	357	1,800	240
8-4	42	290	24
8-5	91	5	22
8-7	47	750	3

TABLE 4.--Properties of pit flume effluents

Plant	Water used (gal. per hr.)	BOD	
		P.p.m.	Lb. per ton of cherries
1	1,060	2,595	4.6
2	3,110	1,070	2.8
3	4,110	1,571	5.4
4	2,810	1,124	2.5

Conclusions

Our findings of this past summer supported our original hypothesis that in the processing of fruits and vegetables there is an opportunity for some real improvements with respect to water usage. We still feel that our processing line survey approach can produce some very useful data. We hasten to add that we also are now very much aware of the amount of labor necessary to elicit this information.

PROBLEMS AND ACTIONS ASSOCIATED WITH INCOMPLETE UTILIZATION OF MAINE AGRICULTURAL RESOURCES

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Since in most, if not all, productive processes there is less than 100 percent efficiency in the utilization of resource inputs in the elaboration of the desired output product, there are other outputs which must be dealt with. These are also resources which in turn may either be utilized in other ways or discarded and thereby wasted. But they are not wastes or pollutants unless they are disposed of or used in ways that are objectionable or detrimental to the rights and privileges of others.

The background and personal biases of an individual or group may well determine whether any given product or process is classified as a pollutant or not. Therefore it is essential that understandable, defensible and quantitatively definable standards be established on a national basis much like the U.S. Public Health standards for certain products. Such standards would ensure National minimums which could be added to by State and local governments, if needed, for more adequate protection. Also, they would prevent the possibility of exploitation in any one region of the country.

Legislative

The State of Maine has recognized a need for regulation of use of resources within its borders so that the integrity of its environment can be both protected and enhanced. Pertinent to this discussion are the (Water and Air) Environmental Improvement Commission Revised Statutes of 1964 -- Title 38 (As Amended) Chapter 3: Protection and Improvement of Waters; and Chapter 4: Protection and Improvement of Air -- Effective October 1, 1969, with Amendments by the First Special Session of the 104th Legislature Effective May 9, 1970. This Commission has numerous duties and responsibilities, including that of "exercising the police power of the State, to control, abate, and prevent the pollution of the air, waters, and coastal flats and to prevent the diminution of the highest and best use of the natural environment of the State." It is also charged to bring future recommendations to the attention of each subsequent legislature.

Four standards for the classification of fresh surface waters have been elaborated, namely, Class A (highest), Class B, Class C, and Class D (lowest). For complete detail the statute must be consulted. In all four categories the waters "shall be free from sludge deposits, solid refuse, and floating solids such as oils, grease, or scum. There shall be no disposal of any matter or substance in these waters which would impart color, turbidity, taste, or odor ... no radioactive matter" ... etc. Other limitations such as dissolved oxygen content, pH, allowable coliform counts and types of coliforms permitted, permissibility or nonpermissibility of discharging properly treated sewage, industrial wastes or other materials, are set forth as applying to one or more classes of these waters.

Five standards for classification of tidal or marine waters have been established as follows: Class SA (having the highest use), Class SB-1, Class SB-2, Class SC, and Class SD (having the lowest use). Definition of permissible uses and limitations with respect to dumping materials, pH ranges, total and special coliform counts, radioactive dumping, treated sewage, and industrial wastes, etc., are likewise carefully delineated for each classification.

Pollution control, enforcement, site location or development and other sections (including protection and improvement of air) are described in necessary detail.

Types of Environmental Activities in Progress or Planned

Because of the very nature of research and educational work associated with the production of food and fiber of animal and plant materials, the personnel of colleges of agriculture (by whatever name) have long been concerned with the maintenance of at least that threshold level of environmental quality consistent with the health and well being of animals and their caretakers. Animal and plant agriculture have long been important contributors to a higher quality of environment for man. These segments of our total complex have been and are significant consumers of innumerable byproducts which otherwise might have been relegated to the category of waste resources and thereby have been considered as pollutants in and of themselves.

Recently, animal and plant agriculture's own "byproducts," in the form of odors and other resources, have come to be considered as pollutants. Admittedly, some of these resources and their questionable contributions to the environment have been ignored by some producers because of their own preoccupation with efficiency of operation and with the simple struggle for economic existence. What is called normal country odors by some is referred to by others as a foul smell. We acknowledge that as commercial agriculture has strained and exceeded the limits of the systems provided for it that some of the odors produced have not had "country kitchen fragrance and freshness."

The use and misuse of animal and plant byproduct resources has been a matter of concern for the agriculturally and environmentally oriented staff of the University of Maine for some time. As a result of these concerns the types of environmental activities engaged in are spread across the campus and show in our teaching, research, and extension programs.

The history of animal science research in this framework has dealt with the techniques of byproduct resource utilization and recycling. Included have been research projects involving the utilization of milk byproducts (such as whey), oil meals and other processed plant food or feed byproducts, yellow grease, feathers, fish meal, etc., which were "wastes" but are now contributors to man's environmental well-being through animals. Research in these areas continues with our current projects.

Contemporary research as reported by Brugman and associates, with certain aspects yet in progress, involves the feeding of sheep in confinement situations in either dirt-floored or expanded wire-floored pens. The sheep are fed sterilized and unsterilized broiler litter, litter containing Amprolium-plus (Ampro) and 3-nitro hydroxyphenylarsonic acid (3-nitro), and a rumen innoculant. Under certain conditions the sterilized litter (113° C. for 11 hours) had significantly lower digestion coefficients for fiber and protein than was the case for the unsterilized litter, but in a subsequent trial, of the reversal type, this effect was negated, indicating the possibility of a carryover effect.

A trial with young lambs indicated that growth was inhibited at an early age by Ampro and 3-nitro and that this effect disappeared when larger lambs were studied. Chemical residues were not found in heart, spleen, 12th rib, kidney, kidney fat, liver or brain tissues of animals fed these materials, although Ampro and arsenic were demonstrable in the poultry litter as fed. In another trial there were no differences between groups in terms of average daily gain except that the group fed Ampro without rumen innoculant did less well than the others. A trial utilizing ruminants' manure with ruminants has been designed and if funded will examine physiologic and metabolic reactions of the test animals over a considerable time. Residue metabolite and other related and highly critical phenomena will be followed.

Dried potato pulp and dried potato byproduct meal have been incorporated in concentrated rations for dairy cows in milk in reversal feeding trials. These have been complemented with digestion trials in which both sheep and bred dairy heifers were used and evaluation was by the Cr_2O_3 indicator method of Kane. When dried potato byproduct meal was fed to high-producing dairy cows at a 22 percent level in the grain mixture (15 percent protein) as compared to the same amount of dried potato pulp, the cows on the meal ate significantly less grain and more roughage. Thus they consumed less dry matter and protein, but more fat and minerals.

This did not significantly affect their milk or major milk constituents, nor did it result in significant changes in their body weight.

A trial was conducted by Gerry using a shrimp meal byproduct in poultry rations. High concentration of shrimp meal in broiler and laying rations is known to impart excessive pigments to broiler meat and egg yolk, but in lesser amounts this material can be effectively used as a ration ingredient.

Similarly, trials by Dr. Muir and others are considering the problems and opportunities associated with growing broilers and layers in cages. Their objective is to reduce the volume of waste created and deal with its disposal in such a way as to make production of poultry meat and eggs more efficient. A long-term trial is about to get underway under supervision of Dr. Brugman and Dr. Dickey to evaluate the effects of feeding significant amounts of broiler litter to dairy heifers from 8 weeks of age to first calving. Other research proposed for an early starting date involves the value of certain other marine byproducts for growing chickens. Our poultry industry has for some time sought procedures for incorporating more of the poultry-processing plant wastes back through broilers and layers as valuable feed ingredients.

Related research conducted by Professor Gershman involves Salmonella serotyping and other microbiological investigations on the quality of the environment in and around production areas of animal agriculture and on the environment in general. Similarly Professors O'Meara and Williams are doing research on the effects of dust and similar airborne particulate matter on the performance of poultry. Professor Klinge is leading research on the land application of poultry and dairy manure where the soil types are known and described. Dried manure (12 percent moisture) is used at a rate of 0-28 tons per acre and undried manure at 75 tons per acre. "Rain" rates are controlled and natural precipitation is also evaluated. Surface runoff is analyzed for NO_3 and NH_4. Soil and ground water samples have been or will be taken at depths ranging from 2 to 48 inches for appropriate analyses.

Research in the nature of plot work and field trials has been done in cooperation with a number of investigators in the Departments of Animal and Veterinary Sciences and Plant and Soil Science to determine the effects of rates, soils, and methods and times of applying animal wastes on corn and pasture lands and to a limited extent on other crops. The use of these materials on corn land appears to offer the greatest potential with the fewest attendant problems. Under favorable field conditions in Maine, maximum application rates for poultry manure have tentatively been set as 5 tons per acre per crop of hay, 12 tons per acre for millet and sudangrass and 20 tons per acre for corn. For summer annuals and corn these recommendations involve incorporating the manure into the soil as quickly as possible. A 3-year trial under the direction of Dr. Hutchinson is determining the dispersion rates of nitrogen and phosphorus from poultry manure as affected by rates of application, methods of incorporation into the soil, soil types and soil profile, degree of slope, and years. Other associated work involves dispersion rates of nitrogen and phosphorus from commercial fertilizers as estimated by the same parameters. Soil and ground water and water table involvement estimates are being made using soil lysimeters and other suitable techniques. Yet other work by Dr. Hutchinson involves the effects of materials used to clear roadways of ice and snow on roadside herbage and surface and ground water (in wells) in areas adjacent to treated roadways.

Dr. Dimond and others are conducting work relative to the effects of aerial spreading of DDT for the purpose of controlling spruce bud worm. They used DDT at the rate of one pound per acre on areas from 20,000 to 500,000 acres in 1958, 1960, 1961, 1963, 1964 and 1967, and studied the effects on the forest environment. The objective was to evaluate what if any is the ecological impact of use of such persistent pesticides. Other work by Dr. Coulter relates to effects of fertilization of spruce-fir sites on both the tiber stands and competing vegetation. Soil chemicals to be worked with are nitrogen, phosphorus, and potassium in a 9-treatment factorial test with 3 replications. Also a related test will involve a 4-treatment randomized block design with 3 replications.

The influence of industrial wastes from a tannery on invertebrates in a tidal bay are being investigated by Dr. Coulter. It was known that a tannery was to be operated on the shore of one cove and so it and a similar cove were analyzed for invertebrate life in 1961. A second survey and analysis was conducted in 1966 and compared with the 1961 data. Periodic observation has continued. During 1970 the tannery was closed, and now that cove will be evaluated with respect to the other in terms of response of the organisms to the new environment where pollution has ceased after almost 10 years of heavy discharge. As of 1966 there was a statistically significant decrease in abundance of Macoma clams, blue mussels, and snails in the polluted area. Extensive residues of shredded leather and fat were observable over extensive surfaces at distances of almost a mile from the tannery discharge pipe. Odors were noticeable and intertidal vegetation was coated to some extent with layers of residue. Beds of eel-grass (important to waterfowl) were not showing visible effects.

Dr. Coulter is beginning a study of snowmobiles in the forest to determine the effect of their operation within prescribed areas on free seedlings and on the general forest environment and population.

An interdisciplinary research program has been initiated to study the pollution of the Penobscot River and its tidal estuaries in order to develop a working model to permit multiple uses for these areas on a continuing basis. Disciplines involved are economics, business administration, civil engineering, sociology, history, chemical engineering, political science, and wildlife management. In the wildlife part of the study, the model is evaluated from an ecological point of view to provide the biological inputs to assist in the formulation of the most efficient model. The water quality standards set by the Atlantic Sea Run Salmon Commission for Atlantic Salmon are being used as the minimum standards for the biological inputs. Additional inputs under consideration involve those water quality standards needed to support certain species of waterfowl.

A research program is currently being conducted by the School of Human Development to determine attitudes of home owners toward the larger environment and their effects on it. A goal is to determine whether or not they would be willing to sacrifice the ease and convenience of individually packaged foods, of detergents, and of other products that cause pollution if they were given information on the environmental problems resulting from the continued use of such products.

An extension service program of an educational nature was inaugurated in 1970 by the Department of Animal and Veterinary Science Extension Specialists (with support of four other departments and involving 17 specialists). Its objectives are to identify that which is known and that which is unknown about animal pollution abatement, and to develop programs to: (a) disseminate the knowledge that does exist and encourage adoption of desirable practices based on this knowledge, and (b) obtain further knowledge by initiating research or by encouraging others to initiate research (including field trials). Thus far educational meetings have been held for both dairy and poultry producers, and one year of a field trial has been conducted using poultry manure at differing rates for corn production. Also, cooperative work is in progress with ASCS regarding building and use of appropriate concrete units for animal manure storage that will minimize manure pile runoff. Some aspects of this overall program have involved cooperation and consultation with the Environmental Improvement Commission regarding the rates of manure application, the location and development of animal production sites, and other specific problems.

These programs indicate that the environment and ecology of Maine have undergone dramatic changes during the past two decades and that they are still changing. A measure of the need for answers can be gleaned from the following sample of statements: (a) over 85 percent of Maine soils are unsuitable for septic sewage disposal (and therefore have other limitations); (b) nearly 50 percent of Maine soils have poor structural characteristics for building foundations; (c) shallow and bedrock soils exist in many areas; (d) less than 13.2 percent of Maine soils are suitable for sanitary land fill operations.

A REPORT FROM
THE PENNSYLVANIA STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION [1]

The projected increase in the world's population within the next few decades emphasizes the need for conservation of existing resources and the development of production systems to use these resources most efficiently. The terms conservation and efficiency both denote recycling of wastes resulting from production and processing of agricultural commodities. There are several "success stories" in the recycling of byproducts through animals, including citrus pulp, soybean oil meal, tankage, etc. Although the feeding of wastes to animals as a major part of the ration is one of the most direct recycling methods, there are many other indirect methods. The use of animal wastes as fertilizers, and the resulting uptake of elements by plants, is one of the oldest methods of indirect recycling. However, with the increased concentration of animal units through larger, more intensive livestock and poultry operations, and with the expanding suburbia, even this recycling media is a hazard to acceptable environmental quality in certain parts of Pennsylvania. Other major waste problems are horticultural processing wastes, whey, milk-house liquid wastes, refuse from paper manufacturing plants, sawdust, etc. Most of Penn State's waste management research is premised on varying degrees of recycling which result in an improvement of environmental quality.

Potential of Recycling Wastes Through Ruminants

Pennsylvania is one of the leading producers and processors of various horticultural crops (apples, tomatoes, potatoes, peas, corn, grapes, mushrooms). The amounts of wastes produced in Pennsylvania by the processing of these crops were estimated from the amount of raw material processed and USDA percent utilization values. These estimates were conducted for each of the nine Pennsylvania Crop Reporting Districts.

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[1] Prepared by L. L. Wilson, Associate Professor of Animal Science; T. A. Long, Associate Professor of Animal Nutrition; H. D. Bartlett, Professor of Agricultural Engineering; A. E. Branding, Research Associate of Dairy Science; and G. O. Bressler, Professor of Poultry Science, The Pennsylvania Agricultural Experiment Station.

The estimated amounts (tons) of each waste were: apple, 89,242; corn, 40,654; grape, 22,780; pea, 2,570; potato, 32,796; tomato, 52,384 and mushroom (including compost), 443,921 tons. The economic value of each waste at different transportation distances from the processing factory, and the number of feeder cattle required to utilize these wastes were calculated. After deduction of transportation costs, the estimated values per ton at 100 miles from the plant (with percentages of dry matter shown in parentheses) were: corn silage (27.6 percent), $3.78; apple (30 percent), $5.28; corn (22.4 percent), $3.09; grape (30 percent), -$2.08; pea (24.5 percent), $2.37; potato (20 percent), $0.95; and tomato (11.1 percent), -$1.69. With the exception of mushroom compost, approximately 56,000 head of feeder cattle would be required to utilize these horticultural wastes fed in an approximate 1:1 ratio with concentrates. Approximately 35 percent of the Pennsylvania waste is from crops produced in contiguous States (11).

Pesticide Deposition in Steers Fed Apple Wastes

The feeding of apple wastes to cattle in the early 1960's resulted in approximately 76 p.p.m. of total DDT deposited in fat tissues of the waste-fed cattle. These results negated the feeding of apple wastes to meat- or milk-producing animals. However, DDT has not been used for pest control in orchards for several years. Total DDT concentrations in fat tissues of steers fed 1.07 tons of wastes (90 percent dry matter) per head averaged 2.17 p.p.m. and ranged from 1.71 to 2.90 p.p.m. Control animals receiving standard cattle feeds averaged 0.41 p.p.m. and ranged from 0.20 to 0.72 p.p.m. These results were obtained with apple wastes from the 1967 growing season. Further trials with wastes from the 1968 and 1969 seasons resulted in slightly less relative amounts of DDT in the steer fat tissues. The DDT concentration was not affected by type of cattle (beef vs. dairy) or by the individual animal's rate of gain or fat thickness. Additional studies feeding activated carbon with the apple wastes resulted in a 24 percent reduction in total DDT concentration in fat tissue of waste-fed steers. Feeding carbon to previously contaminated animals did not increase decontamination rate (14, 12, 13).

Value of Poultry Waste as a Feed for Ruminants

A study was conducted to determine the chemical composition of poultry waste (litter and manure), with a view to its possible utilization as a source of nutrients. Litter samples were obtained from 33 broiler houses and 22 laying houses. Fresh manure was secured from 5 houses having layers in cages. Dry matter content was determined and samples were analyzed for crude protein, true protein, crude fiber, ether extract, and total ash. In addition, 12 mineral elements were determined. Poultry litter contained considerable amounts of nutrients, particularly nitrogen and carbohydrates. Factors such as type of birds, bird density, kind of litter base material, litter depth, and poultry house conditions (ventilation, insulation, and house temperature) all affected the proximate components of poultry litter. Due to these factors and their interacting effects, it is difficult to predict the composition of litter or manure. If poultry waste is to be utilized for its nutritive value for plants or animals, it is recommended that each batch be chemically analyzed before use. Although a limited number of samples was available, variation in composition was sufficient to warrant their individual analysis. In a metabolism trial, wethers were fed a semipurified ration in which the nitrogen was supplied by hydrolyzed or cooked poultry waste, or soybean oil meal. The digestion coefficients for crude protein differed significantly ($P < .05$) between all rations. Nitrogen excreted in the feces was significantly lower for the soybean oil meal ration than for the poultry waste ration. No other significant differences were observed. In a finishing trial with steers, rate of gain, feed efficiency, and carcass grade were not significantly different for beef steers fed rations in which the supplemental nitrogen was supplied as soybean oil meal, hydrolyzed poultry waste, or dried poultry waste. The treated poultry waste rations were readily consumed by the steers and no undesirable effect on carcass characteristics were observed (8, 10).

Subsurface Disposal of Liquid Animal Wastes

Treatments of liquid manure (dairy cows) applied approximately 4 in. below the surface of an established seeding of Pennmead orchard grass were repeated during the 1969 and 1970 seasons (April-July). Application rates of 15, 30, 45, 60, and 75 tons per acre were made in 15-ton increments with successive applications made when soil conditions permitted passage of equipment over the previous application. The treatments were arranged in randomized block design with four replications on 20-by-50-ft. plots. Water samples were taken from suction lysimeters installed in each plot at depths of 1, 2, 3 and 4 ft. (1 each per plot) every two weeks from April to November 1970. The samples were analyzed to determine NO_3-N, organic nitrogen, Cl, pH, and the cations Ca, Mg, Na and K. Grass samples were also taken from each plot for tissue analysis. Samples of the waste were taken for nutrient analysis. The results of water analysis samples show increased NO_3 levels with increased manure application rates, and increased NO_3 level at greater soil depths, with respect to time. At present, NO_3-N levels at 4 ft. for plots receiving 0, 15, 30, 45, 60 and 75 tons per acre for two years in succession are 5, 12, 22, 31, 38 and 52 p.p.m., respectively (2).

Value of Sawdust and Related Materials as Roughage Substitutes

Two trials were conducted to evaluate oak sawdust as a roughage substitute in beef cattle finishing rations. Sawdust was included in rations at

5 and 15 percent levels, with three particle sizes (fine, medium, and coarse) used at each level. Feedlot performance data of both trials indicate that sawdust can be used at levels up to 15 percent of the ration. Results were in favor of the coarser sawdust particles. Carcass characteristics of steers fed rations containing sawdust were not essentially different from those fed rations containing either ground timothy hay or oyster shell.

The incidence of liver abscesses tended to decrease with increases in both sawdust level and particle size. Reduction in liver abscesses was also observed when the hay level in the ration was increased from 5 to 15 percent. Liver abscesses did not significantly affect either performance or carcass characteristics. Rumens of steers fed the rations containing sawdust were parakeratotic. However, improvement was observed when sawdust was included at the 15 percent level, or when coarser particles were used. No apparent problems resulted from feeding sawdust at levels up to 15 percent to beef cattle (3, 7).

Value of Waste Paper as Feed for Ruminants

While not high in feed value, waste paper may be used in relatively large quantities in ruminant diets. It could serve as a source of fiber, as an absorbent for liquids, and as a partial source of energy. Yearling Holstein heifers gained 1.8 pounds body weight daily on a ration that contained 16.5 percent ground paper, corn silage, molasses, and protein supplement (9). The paper ground to medium fineness absorbed up to three times its weight of blackstrap molasses. This dried mixture formed a stable molasses-paper feed product which was highly acceptable to milk cows and heifers. The material tested was a mixture of used magazines and newspapers. Digestibility of the fiber in the paper was about 37 percent. Laboratory studies have indicated that bond paper is more easily digested than is newsprint.

Value of Paper Manufacturing Wastes as Feeds for Ruminants

Ammonium lignin sulfonate (ALS) and ray cells are byproducts of the paper manufacturing industry. ALS, a semiliquid, contains 2.8 percent nonprotein nitrogen (NPN) that may be available to ruminants. Ray cells, actually refined sawdust, have potential as a roughage substitute.

Ammonium Lignin Sulfonate

Because urea is a commonly used NPN source, this compound was chosen to compare with ALS in the in vitro test. Additionally, soy protein served as a control ration. Measurement of ammonia production by the Tilley and Terry in vitro method indicated that ALS and urea have similar nitrogen availabilities. But the nitrogen of these compounds is more rapidly available than soy protein nitrogen.

Following the in vitro test, a sheep metabolism trial revealed digestibilities of three ALS rations: ALS at the 2, 4, and 8 percent dry matter level. Each ALS ration was paired with a urea ration in which the urea supplied nitrogen equal to that of the ALS. All rations contained 40 percent low quality roughage. A trend of decreasing digestibility with increasing NPN level was a consistent feature of this trial.

The final test in the series, a wether feeding trial with 7 animals per lot, used the 6 rations employed in the metabolism trial. The animals fed the 2 percent ALS ration showed the highest daily gain, 0.32 pound; but the sheep fed the corresponding urea ration gained 0.20 pound daily. The 4 percent ALS ration yielded 0.28 pound per day, with the remaining rations producing less than 0.10 pound of daily gain. Feed efficiencies were 1 unit of gain per 6.63 units of feed (1:6.63) for the 2 percent ALS ration; 1:10.15 for the corresponding urea ration; 1:7.47 for the 4 percent ALS ration.

Ray Cells

Ray cells were added to oat straw at three levels: 25, 50, and 75 percent. Also, control rations of oat straw and ray cells were used. All 5 rations had in vitro dry matter digestibilities of approximately 32 percent.

Rations containing 40 percent ray cells are currently being fed to sheep in a metabolism trial. The wethers are consuming about 1200 grams of ration daily or nearly 500 grams of wood cells. Particle size of the ray cells is similar to medium-grind sawdust.

Drying Systems for Poultry Manures for Use in Fertilizers, Mulches, and Animal Feeds

An automatic system of drying poultry droppings inside a poultry house to about 30 percent moisture and to less than 10 percent moisture in a commercial dryer has been developed. Mechanical difficulties in equipment require further developmental work. The dried poultry manure has been applied with a hydroseeder to experimental plots on strip-mined spoilbanks, on divider strips and highway embankments, and on a dam breast. Manure-treated plots were compared with plots treated with lime and fertilizer according to Pennsylvania Department of Highways recommendations. All plots were seeded with a slope mix grass and Crown Vetch seed mixture. By the end of the first summer the growth of grass and vetch on the manure plots was just as satisfactory as on the plots treated with fertilizer and lime. Spoilbanks and highway right-of-way test plots established in 1969 came through the season without serious problems. Color of the manure-treated plots were equal to those treated with fertilizer. Six-acre new spoilbank plots were established in midsummer by use of up to 1300 lb./acre of manure with and without additional nitrogen in form of 80 lb./acre urea + rye grass and Crown Vetch. The 1000 lb. manure + 80 lb./acre urea seemed to be the best. No change in pH or nutrient content of soil was found in any plot established in 1969. Mulching is essential and roughing of traffic-compressed surface before seeding could be beneficial. Use of the commercial dryer operated at 250° F. reduced bacterial counts from as high as 31 billion organisms per gram of manure to as low as 400,000. Enteric type bacteria were reduced from 24 million to as low as 400 per gram of manure. Greater root nodulation has been found with Crown Vetch and beans where dried manure was applied to the soil compared with lime and fertilizer plots. No salmonellae organisms were isolated from the dried manure (4, 5, 6).

Disposal of Milk-House Liquid Wastes

Research is being conducted on the development of a pressure-sensitive, expandable nozzle for use in the distribution of milk-house and milking-parlor wastes through a sprinkler irrigation system (1). Tests were made to determine solids distribution, discharge rate, and nozzle coefficient with pressure variation from 50 to 80 lb./sq. in. gage. An automatically controlled installation for the distribution of these wastes from a 40-cow herd was operated during the 1970 winter and summer seasons. No problems of odors, flies, or ponding were experienced; and the system distributed the materials at the rate of approximately 6,000 gal./day/acre of pasture. It is planned to analyze the soil for pH change, crop yield, and potability, as well as for coliform count and buildup of cations.

Utilization of Cottage Cheese Whey

A study on the utilization of cottage cheese whey has been initiated. Dried cottage cheese whey has been prepared by Lehigh Valley Cooperative Farmers. Using this dried whey and formulae for two of their products, substitutions of dried whey for low-heat powdered milk have been prepared. These products include a fortified skim milk and a low-fat fluid milk. Substitution levels equal to one-half and full equivalents of the powdered milk fortification have been compared with products containing powdered milk as the control. Evaluations were made by a trained panel of 12 women and also by a panel of dairy specialists. Analysis of results are based on duo-trio and hedonic scale data. Data to date suggest substitution of dried whey to be acceptable as a powdered milk substitute from a flavor standpoint.

Variation in Nutritive Characteristics of Aerobically Digested Soft Urban Garbage

A survey has been initiated to determine the variation in chemical composition of domestic garbage within a 12-month period. Currently many methods of disposal are being used, the two primary ones being sanitary landfill and incineration. The use of either primary method presents certain problems that will probably limit their future use. The optimum disposal method would be one that allows waste to be recycled. One recycling method is under development by the Fairfield Engineering Company at Altoona, Pa. Domestic garbage is made into a moist pulp and then digested for 3 to 5 days by aerobic-thermophilic bacteria. The Fairfield Engineering Company has agreed to supply daily samples of the material directly from the digester. After drying, grinding, and mixing, these samples will be analyzed for total nitrogen, crude fiber, and total ash. Calcium, phosphorus, potassium, magnesium, manganese, iron, copper, boron, aluminum, and zinc will be determined by means of a mass spectrometer. Lead and mercury will be determined using an atomic absorption spectrometer. The data will be analyzed statistically and if any differences are found that could be attributed to the day of the week or season of the year, an attempt will be made to determine the causative factor. This survey will also give a strong indication as to the suitability and safety of this material as a fertilizer or as a feed source for ruminant animals.

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A PERSPECTIVE FOR CONNECTICUT

J. J. Kolega
University of Connecticut

The agricultural waste disposal problems for Connecticut have been those primarily associated with the dairy and poultry industry. For the dairy industry, prime examples that can be cited are surface runoff from paved areas; surface discharges into streams or into a drinking water supply watershed, and milking center discharges. A closely related need has been the provision of some form of process treatment for a small milk bottling plant and a large ice cream manufacturer.

Comparatively speaking, the poultry producer has been faced with a more serious problem, mainly because of the small amount of land associated with this enterprise and the corresponding population growth around such operations. For some reason, however, and a fortunate one for the poultry industry, earlier complaints on record with the Connecticut Water Resources Commission were for the dairy industry. Examples of complaints received against the poultry industry by health authorities are those related to odors from poultry housing units or odors during the transport of manure from the egg production center to a land disposal site. A major problem for the State industry, and this probably applies also on a National level, is one of economically developing a process for treating this material or an acceptable method for its safe (health-wise) disposal. Allied industry problems have been those of adequately treating waste from a poultry-processing plant and of obtaining needed design information on the handling of discharges from an egg-processing plant.

One area in the rural and suburban region in a sense has a close tie to agriculture and has been grossly neglected. This problem--a major one which requires a sense of community responsibility--is the handling of septic-tank pumpings. When the problem is examined, one finds that there is little known about the biological, physical, and chemical characteristics of this material or about proper methods for its disposal or treatment. About two-thirds of Connecticut's geographic area is estimated to be using septic-tank disposal systems or their equivalent. The volume to be handled annually is in the vicinity of 80,000,000 gallons.

Some of the Connecticut approaches to solution of the problem, excluding the activities of the Connecticut Agricultural Experiment Station at New Haven (which are covered by another speaker on the program), are as follows. For additional information, contact the person whose name is underscored.

Research

University of Connecticut

(1) Disposal and Utilization of Dairy and Poultry Manures by Land Application.

Cooperating Departments: Agricultural Engineering (J. J. Kolega) and Plant Science (R. W. Wengel).

Date project initiated: July 1, 1968.

Termination date: June 30, 1972.

(2) Treatment of Poultry and Cattle Farm Wastes Combined with Domestic Sewage by the Activated Sludge Process.

Cooperating Departments: Civil Engineering (R. Laak, C. Shu) and Agricultural Engineering (J. J. Kolega).

(3) Treatment Processes--Wastes Pumped from Septic Tanks. U.S. Department of Interior FWQA Study.

Cooperating Departments: Agricultural Economics (A. W. Dewey, R. Leonard); Agricultural Engineering (J. J. Kolega, W. C. Wheeler); and Microbiology Section of Biological Sciences (B. J. Cosenza).

Collaborators: Connecticut State Department of Health, Environmental Health Services Division; the Metropolitan District Commission, Bureau of Public Works (Hartford area); the Connecticut Sewage Disposal Association; and the University of Connecticut Civil Engineering Department.

Extension

University of Connecticut with cooperators as noted.

In this area, the activities on a State-wide basis reflect the more serious position of the poultry producer. A number of different approaches are being tried or investigated in an attempt to provide solutions for already existing problems. These are:

(1) Maxi-Mix

Cooperators: USDA Agricultural Stabilization and Conservation Service; USDA Soil Conservation Service.

University of Connecticut Extension personnel: W. A. Aho, G. F. Griffin.

(2) Forest Fertilization

Cooperators: Connecticut Agricultural Experiment Station, New Haven (G. Stevens, D. Hill).

University of Connecticut Extension personnel: W. A. Aho, J. J. Kolega.

(3) Subsoil Manure Disposal

Cooperator: T. Roberg, Litchfield, Conn.

University of Connecticut Extension personnel: W. A. Aho, W. W. Washko.

(4) Odor Control

Cooperators: State poultry producers.

University of Connecticut Extension personnel: S. Hale (now retired), W. A. Aho.

(5) Fly Control

Cooperators: State poultry producers.

University of Connecticut Extension personnel: W. A. Aho, F. Streams, J. Rock, E. Prout, A. Spandorf.

(6) Recycling Poultry Manure

University of Connecticut Extension personnel: A. Spandorf.

In connection with some of the poultry activities, there has been some financial support from the State poultry producers' association, but the amount has been minimal.

Interestingly enough, a similar listing cannot be cited for the dairy area; although a listing could be made of a few producers who have been asked by either the Connecticut Water Resources Commission or the Department of Health to take corrective action as it relates to water pollution control.

There is also a State-wide farm-waste management committee consisting of representatives from the University, Connecticut Department of Health, Water Resources Commission, USDA Soil Conservation Service, USDA Agricultural Stabilization and Conservation Service, representatives from the dairy and poultry industry, dairy division of the Department of Agriculture and Natural Resources, and the Connecticut Agricultural Experiment Station located at New Haven. One objective of such a group is to provide a mechanism for liaison between agencies who are encountering agricultural waste-disposal problems. The committee has a genuine interest for the problem at hand. Recently, it has undertaken the initiation of some educational publications on selected aspects of pollution.

A relatively new problem area for Connecticut has been related to the influx of pleasure horses. At present, we have no general recommendation on the handling and disposal of feces and urine from these animals, nor do we have a good answer to the amount of land required per animal (site size) as it relates to possible pollution hazards.

To stimulate discussion and thinking or suggest research needs, I conclude with the following remarks:

(1) It is considered a good practice to use the procedures outlined in Standard Methods for Waste Disposal Analysis. However, with certain laboratory tests--particularly for some of the high-strength agricultural wastes--is this the procedure to use, or should better and more meaningful methods be developed?

(2) An engineer involved with the design of processes for agricultural waste disposal and treatment will use available research data. Are these numbers a representative value, statistically speaking? Considering the method of sample collection, number of samples collected, the number of installations, or different groups required, etc., what are the "ideal guidelines" for the researcher developing such information?

(3) The interdisciplinary investigation team is important and valuable. It is not always simple to implement, but it is not an approach that should exist on paper alone for the purpose of obtaining funds or satisfying administrators. Based upon Connecticut experiences, the practice of bringing experts together, either on an active or collaborator basis, is to be encouraged if it is applicable to the research contemplated.

(4) What are the water quality standards to be used by agriculture for soil water?

(5) One solution is not necessarily the answer. It is perhaps desirable to offer a number of alternatives and let the local situation determine method selection based upon factors such as economics, land availability, and availability of qualified personnel if needed.

PLANT NUTRIENT BUDGETS AND WASTE DISPOSAL

C. R. Frink
Connecticut Agricultural Experiment Station

By way of introduction to the problems of waste disposal, I would like to remind you that as a society we must perform a number of functions in order both to live and to enjoy life. Among these are feeding ourselves, disposing of our wastes, obtaining clothing and shelter, and last, but certainly not least, providing beauty and recreation.

Some of these functions result in undesirable side effects on our environment. In particular, one of our most pressing environmental concerns in Connecticut is the enrichment of our lakes and streams with plant nutrients that encourage the growth of weeds and algae. In addition, there is increasing national concern over the possible health hazards to infants and ruminant animals from high concentrations of nitrate in food and water.

The nutrients responsible for these problems may come from fertilizers, animal or human waste disposal, or erosion from a new housing development. Our job, as I see it, is to examine how we may best carry out these functions with the least damage to our environment.

A useful perspective on the magnitude of the problem of nutrient pollution may be obtained from an analysis of nutrient budgets for a farm, a watershed, or a State. Table 1 shows some estimates of various plant nutrient sources in Connecticut (3). Note that these are not mutually exclusive sources: nitrogen from feed and fertilizer, for example, appears in both human and animal wastes.

Even in urban Connecticut, animals produce about as much nitrogenous wastes as humans. Phosphorus in domestic wastes exceeds that in animal wastes, since as much as half the phosphorus in domestic sewage has been attributed to detergents. At least 60 percent of these domestic wastes are treated in sewage treatment plants, so that the soil filter is bypassed and nutrients are discharged directly to streams.

Most of the nitrogen used in agriculture enters the State in the form of dairy and poultry feed, rather than as fertilizer. Of the total fertilizer used in the State, nearly 40 percent is sold for nonagricultural purposes. Since much of this is spread on lawns where no crop is harvested and removed, this may well be an important source of nutrient pollution.

TABLE 1.--Estimates of plant nutrients from various sources in Connecticut

Source	Plant nutrients (tons)		
	Total material	Nitrogen	Phosphorus
People - 3,000,000	1,500,000	13,500	4,500
Cows - 100,000	1,500,000	7,500	1,600
Broilers - 12,000,000	240,000	3,600	840
Layers - 4,000,000	80,000	1,200	280
Dairy and poultry feed	444,000	13,300	3,100
Dairy farm fertilizer	26,100	2,500	1,300
Other agricultural fertilizer	29,100	2,100	1,000
Nonagricultural fertilizer	25,600	2,800	1,400
Protein produced in Conn.	--	3,800	--
Protein imported into Conn.	--	14,000	--
Automobile exhaust	--	38,000	--
Industrial fumes	--	44,000	--

Finally, the nitrogen oxides produced during high temperature combustion are another large and uncertain source of nitrogen. Presumably, these oxides return to the earth as nitrate nitrogen in rainfall. If all the oxides estimated to be produced in Connecticut actually returned in rainfall, we would have no need for fertilizer, since they amount to about 55 lb. of N per acre per year. Obviously, this is a source which we need to know more about.

Agricultural productivity in a State is usually measured in terms of cash income or size of the labor force, both of which are quite small in Connecticut. However, our small but viable agriculture produces fully 20 percent of the animal and vegetable protein consumed in the State, which is equivalent to feeding 20 percent of our population, or 600,000 people. This food is produced by about 2,000 farmers, which means that 300 people depend on one farmer for their protein. When expressed in these terms, our dependence on agriculture is more readily visualized.

We also rely heavily on agricultural land to dispose of our wastes, both human and animal. An outstanding example of the value of land for human waste disposal was the recent disposal by the city of Hartford of an estimated 100,000 cubic yards of digested sewage sludge. Lunt (4) had earlier shown that sludge is a satisfactory fertilizer if the soil is limed to pH 6.0 or higher to prevent heavy metal toxicity. Thus, the sludge was trucked to a commercial nursery occupying about 1,000 acres in the Connecticut River Valley, a solution pleasing to both the municipality and the nurseryman.

Not all agricultural land grows annual crops: about two-thirds of Connecticut is forested and could benefit considerably from the nutrients in wastes. Stephens and Hill (5) are now investigating the utilization of liquid poultry manure by a stand of white pines in Pachaug State Forest in eastern Connecticut. They seek to determine the following: loading rates that will not endanger the vegetation or the ground water; the effect of added nutrients on tree growth and nutrient retention in trees, soil and litter; and effects on microbial populations, fly breeding, and recreational uses of the forest.

The largest single source of plant nutrients in Connecticut, apart from human waste, is dairy farming. Accordingly, I have examined the efficiency of nutrient utilization on dairy farms both in Connecticut and the Northeast. The results of these studies have been published elsewhere (1, 2) and are summarized here briefly.

Dairy farms were considered as factories for the conversion of nutrients in feed and fertilizer into outputs of milk and meat. The efficiency of nutrient conversion was found to depend on available crop land per cow, with efficiency decreasing dramatically as farm size decreased. Nutrients not converted into usable outputs were considered lost from the system. Phosphorus and potassium are readily fixed by soils and were, therefore, assumed to accumulate in the fields. Nitrogen, however, is readily leached and would presumably find its way to nearby waterways.

These data indicate that every effort should be made in the Northeast to keep land available so that crops may utilize the applied nutrients more efficiently. Other agronomic approaches to reduce losses of nitrogen include applications of fertilizer and manure to growing crops rather than to bare or frozen soil, selection of crops with both high yield and high protein content, increased plant populations, and more extensive use of cover crops.

It appears to me that our remaining crop land must be made to do double duty: absorb and utilize our wastes, thereby reducing the total amount of nutrients we must import into the State; and thus enable us to produce the necessary farm products with less damage to the environment.

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ANIMAL WASTE MANAGEMENT IN MODERN PRODUCTION SYSTEMS

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The numerous self-contained small family farms of the early part of the century had no problems of disposing of animal wastes. Manure was the principal source of natural fertilizer and on well-managed, small fixed farms, it was usually in short supply. The activity of the farmer in disposing of manure on his land was of little concern to his neighbors who followed similar practices.

This has all changed. The economic pressure to concentrate animals for the efficient use of labor-saving equipment and the need for environmental control for maximum productivity have led to the development of high-density animal confinement systems. It is not uncommon for poultry farms with relatively few acres of land to confine 100, 000 to 200, 000 laying hens in a closed system. This operation produces a waste-disposal problem equivalent to that of a city of 10, 000 to 20, 000 people, as well as an odor that can pervade a wide area. Other types of livestock systems, such as beef-cattle feedlots, confinement hog operations, and more recently the trends to slatted-floor confinement for dairy cattle, produce similar problems.

Farmers have new neighbors. Not only have city dwellers moved to his community to live in a rural atmosphere, but also the development of large resort activities in areas that were once classically agricultural has brought people into the rural area who often have a different opinion about the definition of environmental quality.

As agricultural specialization, intensity, and productivity have increased, problems of disposing of liquid, solid, and gaseous byproducts have greatly intensified. In addition to the conflict of interest over the environmental quality is the mammoth problem of disposal of large amounts of solid wastes. These are not only extremely offensive but have the potential of polluting both surface and subsurface waters.

A comparison of municipal waste with agricultural waste shows some interesting differences. A city of 20, 000 persons may easily cover an area of 4 or more square miles. Its sewage treatment plant designed for primary and secondary treatments may cost from $100 to $200 per person with a capital investment in the millions of dollars. A poultry farm of 200,000 hens, an operation of 1,200 head of dairy or beef cattle, or of 10,500 hogs may each produce a waste-disposal problem equivalent to the city of 20,000 people. In many cases, the poultry or livestock farms may be concentrated on a relative few acres. In addition, it is usually isolated from other poultry or animal enterprises so that cooperative ventures in waste-treatment facilities are not feasible.

Agriculture cannot ignore its responsibility for any adverse effect that it may have on the total environment. It is now absolutely essential that the cost of a livestock operation must include the waste-handling and disposal activity as a total part of the management system. All of this has to be done within the economic constraint of the operation, within legal restrictions in terms of air and water pollution codes, with due respect for public relations where agriculture is close to resort or residential areas, and with full recognition of the social and political implications if agriculture does not attempt to control its pollution problems (3).

The problems of animal waste disposal are complex. They include not only the engineering but also the social, legal, and economic aspects. Waste disposal can no longer be handled as an afterthought in the management procedure but must be part of the whole production management design. Overall research on problems of this nature pose a problem in the structure of many agricultural colleges. The solution requires the input from several traditional commodity departments. Therefore, a different organizational approach is necessary to coordinate the research and extension programs to solve the problems of animal waste disposal and pollution.

In the College of Agriculture at Cornell University an Interdepartmental Task Force was formed with representatives from the Departments of Agricultural Economics, Agricultural Engineering, Agronomy, Animal Science, Food Science, and Poultry Science. Staff from these departments are the active participants in the Agricultural Waste Task Force. They are responsible for the identification of priority areas and for the development of project proposals to obtain the funding necessary to carry out the research. At the same time other task forces, one in pesticides and chemical pollution and one in water resources, coordinate programs in other interdepartmental problem areas.

A great deal of investigation has been conducted at Cornell and elsewhere in disposal systems, identification and control of odors, prevention of water pollution, removal of nutrients, reutilization of animal wastes either as fertilizers or feedstuffs, and new methods of waste management which can become economically part of the total production system.

Research programs at Cornell have been concentrated in several areas. These have included the economics of manure disposal; the chemical, physical, and biological properties of animal manures and of the odor components from these manures; the various means of handling waste products; the reutilization of these wastes; and nutrient removal from waste water.

The economics of waste management practices was studied in Sullivan County in New York State, where a population of 3.5 million laying hens was near a $60 million resort industry (4). The report was made in 1966 when poultrymen were initiating various systems to try to reduce odors. It showed that the various poultrymen's situation differed and that many methods for reducing the waste disposal problems were being tried. The manure disposal systems in use included increased land spreading with improved equipment and storage facilities so that spreading could be done in the spring and fall when odors would not interfere with the resort industry. In most cases the cost of manure disposal was minor in terms of total production costs. However, costs became more significant when margins to producers were narrow and where special operating standards for manure handling were required. For farms without storage or special handling equipment, waste-disposal costs averaged 9 cents per bird or 0.5 cent per dozen eggs produced. Installation of manure storage facilities and adoption of improved handling methods raised the annual cost to an estimated 13 cents per bird or 0.75 cent per dozen eggs. In addition to the operating cost, the initial investment was estimated at 22 cents per bird to store the manure for 3 months and 35 cents per bird to store it for six months.

The report showed that dairy and crop farmers had the potential for greater land spreading in this poultry-and-resort area. The greatest single deterrent to increased spreading was the cost of transportation which was estimated at a dollar per round-trip mile for road vehicles. Based on the replacement value of nutrients in commercial fertilizers, poultry manure was valued at $1.66 to $3.00 per ton.

Reduction of the odors that emanate from within the house and are ventilated by the powerful exhaust fans is still a problem. Earlier recommendations proposed the addition of water to manure handling systems. Diluted manure is easier to handle, but under the anaerobic conditions in the deep pits under the cages, it develops extremely offensive odors. These odors are particularly obnoxious not only in the exhaust ventilation air from the poultry house itself, but to an even greater extent when the manure is spread on the land. Extensive research has been conducted on the nature of the odor components and the factor which contributes to odor in both diluted and undiluted poultry manure.

A combination of gas chromatographic and organoleptic techniques have been used to determine the chemical components responsible for the offensive odors in liquid poultry manure and also to determine the odor strength of manure tested under a variety of conditions either in terms of management systems or with chemical masking agents or counteractants (6).

Undiluted and diluted forms of chicken manure differ in the production and release of gases and odors. Both undiluted and liquid forms have comparable odor strength, but the liquid form has a more offensive odor than the ammonia-like smell of undiluted chicken manure. When liquid manure is agitated, odors are released and their strength increases rapidly. In addition to ammonia and hydrogen sulfide, a number of organic compounds with distinct odors have been identified. These include the C_2 to C_5 organic acids, indole, skatole, diketones, mercaptans, and sulfides. The worst of these are organic acids, mercaptans, and sulfides. Also implicated in the offensive odor group are skatole and amines.

Some 40 to 50 different commercial odor-control products were evaluated in terms of their suitability for liquid poultry waste. Of these the masking agents and counteractants were found to be slightly effective. Deodorants were moderately useful and digestive treatments (enzymes and bacterial starter cultures) were less effective. None of the chemicals tested were considered to be entirely successful in controlling manure odors and only a few of the compounds tested could really be recommended for use, and then only in emergency because of the high cost of the products themselves (2).

The best procedure for controlling air pollution is to prevent the formation of the odor compounds. These compounds are formed under the action of anaerobic bacteria and develop with continued storage under anaerobic conditions. Therefore, to reduce odors effectively, either moisture must be removed rapidly from the manure, particularly when the manure is fresh, or the manure if diluted must be aerated to get more complete oxidation.

Research is under way to study the feasibility of the oxidation ditch in poultry houses. This system has been used successfully with hog-growing units where the following operating criteria have been followed. A ditch liquid volume of about 30 cubic feet per pound of daily biological oxygen demand (BOD) is required with a liquid depth of 2 feet or less to maintain sufficient velocity to prevent the settling of solids. The aeration rotor should have an oxygenation capacity twice that of the daily BOD loading. Preliminary results with this type of system under laying hens resulted in excellent odor control after the development of nitrification bacteria which control the large amount of ammonia given off in the early start-up period.

Foaming has been observed at times in the oxidation ditch. The factors contributing to this condition are not completely understood and are now under investigation.

Another system of oxidizing large volumes of liquid waste is the aerated pond. In this case large surface aerators incorporate air into the water to maintain an aerobic system. This system is being used extensively by the duck growers on Long Island. It also has application to other types of livestock and agricultural wastes such as dairy wastes where large amounts of liquid prevent the use of dry systems.

On the other hand, the removal of moisture has several advantages. In addition to reducing odors, it reduces weight and volume, improves handling characteristics and the drier product becomes more suitable for reutilization. At the present time, research effort is directed towards management practices and handling equipment that permit economical moisture removal.

One of the management systems now being built into new poultry houses is the deep pit (up to 8 ft.) under the entire house. For this system to function without producing severe odor problems, it is absolutely essential that it be kept dry. This means that water from the drinking system and all surface and seepage water must be kept out of the pit. In addition these deep pits must be force ventilated in order to remove the moisture from the manure itself. The moisture level in the manure should be rapidly reduced to considerably less than the moisture in fresh manure in order to prevent the system from becoming anaerobic and causing severe odor problems.

Systems which have been studied at Cornell include the following:

Incineration

Poultry manure with more than 30 percent dry matter will sustain oxidation and can be incinerated. Manure which is more than 70 percent moisture must be partially dried or fuel must be added. Care must be taken to control air pollution. The major drawback is the capital investment, the cost of operation, and the continual supervision necessary.

Dehydration with Heated Air

Dehydration to less than 20 percent moisture is another possibility. Again the dry system of manure collection must be used. Although cost depends on the moisture content of raw manure, it averages about twenty dollars per ton of dry product. The solid waste product is often difficult to market as fertilizer. However, where markets are available, the system is being used and has possibilities. The product is also suitable as a feed ingredient for cattle.

Drying With Unheated Air

Air drying to a moisture content of less than 45 percent, using unheated air, is receiving considerable research attention since it offers an economical method for controlling odors. This system can be used in conjunction with either incineration or land disposal. Research is under way to develop various management systems which may provide other alternatives for the control of odors emanating from the ventilation fans of laying houses.

The reutilization of dried chicken manure not diluted with litter as a nitrogen source for ruminants was studied in three trials at Cornell (1). The average composition of the dry matter of chicken manure was crude protein, 36.9 percent; total carbohydrate, 34.4 percent; ether extract, 1.4 percent; ash, 27.4 percent; calcium, 9.3 percent; and phosphorus, 1.5 percent. The manure provided 3,290 kilocalories per kilogram. Air-dried manure contained 81 percent dry matter. This material, when ground and uniformly mixed with high-energy grain such as ensilaged high-moisture shelled corn, was a good source of nutrients for dry and lactating cows. After an 18-day adaptation, dry cows consumed from 2.5 to 4.5 pounds of dry manure per day as part of a concentrate, while lactating cows consumed 5 to 9 pounds per day. Animals consuming the dried manure as part of their ration showed the same weight gains, milk production, and milk flavor as those fed the controlled ration. Additions of dried chicken manure to a low-nitrogen basal diet resulted in an increase in the digestibility of the dry matter, energy, nitrogen, ether extract, and carbohydrate.

Numerous management practices are available today for the land application of poultry waste (5). All of these depend on a manure-collection system within the house and a storage facility either under the cages or adjacent to the house. This permits the poultryman to select the time of year in which the manure can be spread on the land. This is particularly important if a liquid or wet system is used and the diluted poultry manure is spread by flail spreaders or by irrigation systems.

Heavy application of liquid poultry manure has been used to kill undesirable weeds and brush growth which will eventually be replaced with forage grasses. Heavy application on corn land will markedly improve corn yield but also can be deleterious in dry seasons because the accumulation of plant nutrients in the soil may be deleterious to the plants if soil moisture is low. Very heavy applications of manure can lead to stream pollution due to surface runoff or the movement of nitrogen through the soil with the potential of polluting subsurface waters.

Rutgers University has developed a soil injection technique, equipment for which is now commercially available. This system permits the injection of liquid manure some 8 to 10 inches below the surface in a manner which completely traps odors. At the present time, the movement of nitrogen through the soil is being investigated to determine whether this may be a potential drawback to the system. The technique is best adapted to sandy-type soils and is not as applicable to many of the heavy soils common to New York State.

The potential danger of nitrogen contamination of surface and subsurface waters from the application of manure to various cropping systems is being studied at the agronomy research facility at Cornell. These facilities permit constant monitoring of the surface and subsurface waters to determine the movement of plant nutrients. With this type of information, it should be possible to predict the maximum rate of land application of manure to avoid pollution of ground waters with excess nitrates.

Careful consideration must be made of the various animal waste handling and disposal systems to avoid transfer from one type of pollution to another. The use of drying and incineration may cause air pollution or heavy land disposal may result in surface or subsurface ground water pollution. Odors can be generated by poorly managed storage tanks or poorly timed land spreading.

The design of animal production units of the future must take into consideration the conditions necessary for optimum production with the management system which will minimize environmental pollution. There is no longer "another place" into which waste materials can be discharged without intruding upon the living space of someone else.

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TREATMENT AND DISPOSAL OF ANIMAL WASTES IN MASSACHUSETTS

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Agricultural waste processing systems cannot be designed rationally and with confidence until information is gathered on the parameters related to the performance of such systems. One indication of the urgent need for such information is the following: Last year in Massachusetts preliminary hearings were held to consider whether agricultural enterprises should continue to be exempted from the requirement made of other industries to secure a "sanitary engineering works" permit before undertaking construction of required physical facilities.

Over a period of time reasonably successful, although mostly empirical, methods have been developed for predicting the performance of municipal (and some other types of) waste treatment systems. At present equivalent data relating to the design and performance of agricultural waste treatment systems does not exist. In attempts to provide usable engineering design information, separate, but not isolated, studies of several components of treatment systems are being carried out.

Extended Aeration

We are evaluating what might be called an extended aeration system, a modification of the activated sludge system, which ordinarily consists of five parts: (1) screening to remove large solids, (2) primary sedimentation, (3) aeration, (4) secondary sedimentation, and (5) anaerobic sludge digestion. Extended aeration consists of steps 2, 3, and 4. In our system a day's manure from one animal (perhaps 70 pounds of total wet material, containing about 10 pounds of solids) is mixed with water (about 30 gallons) to form a 3 to 4 percent slurry. The water serves as a transport medium (we may be using more water than is necessary). The slurry is then subjected to continuous aeration with an excess of oxygen (2 to 3 percent dissolved oxygen). The output from the aeration chamber goes into a secondary sedimentation chamber, and the effluent from this is disposed of in the soil at a subsurface level.

[1/] Researchers, in addition to the author, engaged in the work summarized include Professor L. F. Whitney and Research Assistants F. S. Chuang, R. E. Graves, and V. B. Pandey.

Disposal of the effluents from this treatment system in subsurface fields is being studied in terms of the effects of the effluents on selected chemical, microbiological, and physical properties of constructed soil profiles. The degree of tertiary treatment that takes place in the soil is also being considered.

The experiment is a 4 x 2 x 3 design, with 4 effluent treatments, 2 soil bulk densities, and 3 replications. The soil profiles, constructed from an "agricultural" soil common in western Massachusetts, were placed in concrete cylinders 30 inches deep by 30 inches in diameter, with a porous plate at the bottom. The effluent from the liquid manure treatment is introduced 12 inches below the surface of these columns of soil by means of a plastic tube with a polyvinyl chloride nozzle. The characteristics of the nozzle are given below.

The effluents were run through the soil columns at 4 different rates per square foot of surface area, as shown in table 1: T-1, 4 gallons per day; T-2, 1/2 gallon per day, with aeration on alternate days; T-3, 1/4 gallon per day; and T-4, 1/4 gallon per week. Both the soil and the percolate water are analyzed weekly, and statistical evaluation of the data are made after no less than 26 weeks of operation. Selected values for the 26th week are shown in table 1. In addition to the data shown in the table, other evaluations are being made, such as total numbers of soil fungi, actinomycetes, changes in soil bulk density, and soil NH_4O Ac extracted for exchangeable K, Ca, Mg, Na^+. From the data in table 1, it appears that T-2 and T-4 are better than T-1 and T-3, indicating that periodic rather than constant application permits the soil to absorb the material more efficiently, allowing the soil to retain its permeability and causing less clogging.

Device for Uniform Discharge of Effluents

A principal objective of this study was to develop a system for distributing animal waste effluents within the soil with an orifice or nozzle that can reliably effect uniform discharge. Variables related to effluent particle size, flow rate, pressure head, coefficients of discharge, etc., are considered.

Molded plastic insert nozzles and machined, covered, in-wall orifices are being studied and evaluated. The nozzle design is based largely on work previously reported, but modified appropriately with a 1/8-inch orifice to account for the impurities and biological particles in the effluent. The features of the nozzle are: (1) entrance to the orifice extends into the center of the distribution lateral pipe where velocities are at a maximum; (2) sediment within the pipe is less likely to clog the orifice; (3) coefficients of discharge for all orifices are carefully controlled by the plastic molding process; (4) discharge from the orifice is through a labyrinthian passage which protects the orifice from plugging by soil particles.

TABLE 1.--Analyses of soil and percolate water for liquid manure passed through 30-by-30-inch columns of soil (typical data obtained after 26th week of treatment)

Characteristic	Effluent as applied to soil	T-1	T-2	T-3	T-4
		Saturated flow	Effluent aerated on alternate days	Daily dosing	Weekly dosing
		4 gal./day/ft.^{2}	1/2 gal./day/ft.^{2}	1/4 gal./day/ft.^{2}	1/4 gal./wk./ft.^{2}
BOD (p.p.m.)	150-250	11	5.5	9	5
COD (p.p.m.)	900-1,100	49	23	57	22.5
Total solids (pct.)	0.24	0.33	0.16	0.22	0.13
Total nitrogen (p.p.m.)	124	25.3 (63.5)*	6.76 (48.7)*	11.8 (66.7)*	10.5 (52.8)*
Nitrate (p.p.m.)	68.5	285.2	610.0	322.4	192.2
Particle size (mm.)	0.5	-	-	-	-
Fecal Coliform (no./ml.)	1,300	175	120	135	115
Fecal Strep. (no./ml.)	890	695	615	670	590
Organic matter (pct.)		(4.64)*	(4.29)	(4.46)	(4.33)
Flow rate (gal./min.)		0.037	0.067	0.0416	0.0625
Volatile solids (pct.)	59.8	60.77	54.99	60.36	59.59

*Values in parentheses are for soil; other values are for percolate water.

Covered in-wall orifices (1/8-inch diameter) are machined into stainless steel pipe to eliminate the effects of corrosion or nonuniformity. An external, concentric pipe cover with a 1/8-inch orifice outlet surrounds the inner orifice to form a labyrinth, thus providing protection from soil particles. The orifices were oriented precisely with the outlet at the bottom of the cover.

The performance of sewage effluent discharging from individual orifices have been analyzed prior to and after placement in the laboratory soil mounds with the following results: A polyvinyl chloride plastic insert nozzle allows for a more uniform coefficient of discharge and produces uniform sewage effluent distribution in a subsurface system. It was found that covered in-wall orifices were clogged by organic and/or soil particles after 3 months of laboratory study.

In-wall orifices have been concluded to be unreliable and to give nonuniform output. The plastic insert nozzle protects against internal as well as external clogging by organic or inorganic particles. Engineering data and statistical analysis support the conclusions in detail. The projected costs are low enough to make the system economically feasible.

Additional reliability data will be provided when analysis of the study is completed. Flow rate analysis will relate to the change in soil permeability and the orifice maintenance within the nozzle.

Stationary Sloping Screen

To separate solid material from dairy cattle manure slurries, we have evaluated the performance of a stationary sloping screen (Welles Products "Elimin-Ator"). The slurry flows in a thin layer over a screen made with precisely shaped and spaced transverse stainless steel bars. The shape of the bars and the multiple slopes of the screen are designed to aline particles for best screening separation.

Tests were made on a bench-scale screen using 4 different bar spacings (0.060, 0.030, 0.020, and 0.010 inch). The screen were narrower and approximately 1/3 the length of those installed in the field. Flow rates were visually controlled to approach operation of a normal screen. Water manure slurries were varied from 1:1 to 20:1 (water to wet manure by weight).

Reduction in total solids in the effluent from the screen varied from a low of 34 percent for the 0.060-inch bar spacing and 20:1 slurry to a high of 75 percent for a 0.020-inch bar spacing and 5:1 slurry. Settleable solids of the effluent varied from 16 to 140 ml./l. Additional data were collected for the 0.020-inch screen. Fresh manure in a 5:1 slurry (approximately) was screened and the solids were analyzed. Typical data for the solids removed are as follows:

Moisture content	87-92 percent
Volatile solids (dry basis)	94-95 percent
Organic nitrogen	1.1 mg./g. wet solids
Ammonia nitrogen	0.13 mg./g. wet solids
Crude protein (dry basis)	9.3 percent
Crude fiber (dry basis)	31.0 percent

The solids removed appeared much like very wet sawdust. Excess water removed with the solids readily drained from them on standing. No odor considered objectionable was produced by solids left in the laboratory, and flies were not especially drawn to the material. The materials should be easily handled and stored with conventional manure handling methods. Although obviously organic, the solids do not contain the more readily decomposible portions of the slurry, which remained as small particles and soluble material in the screen effluent. The solids were probably not "washed" as much as those removed from a vibrating-type screen.

A screening process such as this for treating manure slurries is expensive. One was sold to a duck farm operator for $5,000. Of course, its cost is largely dependent on the volume of material it is designed to handle. Its advantage is that it is a stationary installation. If it can be made to separate 75 percent or more of the solids in a slurry, and if these solids are relatively stable and can be disposed of easily, then the system can be scaled down and perhaps made small enough to be economically feasible.

Reuse of Effluent Water

A bench-scale experiment was made of this screened effluent to determine whether or not the water used to dilute and transport the manure could be renovated and reused. The effluent was treated in two ways: with primary settling, aeration, and final settling; and simply with aeration and settling (no primary settling). Then to determine the effect of reuse of water, both systems were operated identically, but one used distilled water for slurry preparation, and the other used slurry made up from system effluent. The systems were loaded daily for 15 weeks. No adverse effects on the treatment were noted due to recirculation. BOD reductions of better than 95 percent, and COD reductions of better than 90 percent were achieved. But as table 2 shows, the solids content was about 50 percent higher in the system using recirculated effluent instead of fresh distilled water. There was also a sizeable increase in chlorides, a tripling in nitrates, and an increase in phosphates where the effluent water was recirculated. Bacteriological tests for Fecal Coliform and Fecal Streptococcus indicated a

90- to 99-percent reduction achieved in all systems. No appreciable buildup of these organisms was noted in the recirculating systems. Inconclusive tests indicated a slight bactericidal effect of the recirculated effluent on the organisms in fresh manure, but it does not seem to be nearly so severe as some predicted it would be. It appears from these experiments that it might be quite possible to reuse water for many cycles.

TABLE 2.--Analysis of liquid dairy cattle manure treated by 2 systems using fresh distilled and recirculated water

Characteristic	Fresh distilled water		Recirculated water	
	System A*	System B**	System A*	System B**
Total solids (pct.)	0.18	0.16	0.25	0.24
Volatile solids (pct., dry basis)	55	53	53	54
Chlorides (mg./l.)	80	72	117	103
Nitrates (mg./l.)	1.3	1.2	4.5	6.7
Phosphates (mg./l.)	800	600	1,120	700

*System A: Primary settling, aeration, final settling.
**System B: Aeration and settling only.

Nitrogen Flow Through Soil

Since effluent from any system is likely to be applied to the soil regardless of the extent of treatment, a laboratory study is being conducted to determine the flow of nitrogen through a porous medium. The purpose of the study is to establish what effect the well-known adsorption of nitrogen by soil particles would have on nitrogen contamination of ground water in the vicinity of waste stabilization ponds.

Bench tests and column tests have been made on soil obtained about 5 feet below the surface in the vicinity of duck manure stabilization ponds that have been in operation for about 7 years. In the bench tests adsorption capacities of the soil were determined for different concentrations and different flow rates of nitrogen-carrying influents. Adsorption values for ammonia nitrogen, nitrate nitrogen, and nitrite nitrogen have been determined. Concentration levels have varied from 20 mg./l. and contact times were 5 and 8 days. Physical and chemical characteristics of the soil were determined and care was taken to minimize biological activity. All tests have been carried out at approximately 60° F. (15.5° C.), a representative subsoil temperature. The adsorption data obtained follow Freundlich, Longmuir, and B.E.T. isotherms, for which values of constants have been determined. As solution concentrations increased, adsorption of nutrients increased, and equilibrium for ammonia nitrogen was reached slowly.

In the column tests, information was obtained for natural flow conditions in the soil. In these tests the main variables were rate of flow and influent concentration. NH_4-N, NO_3-N, and NO_2 were each used at 4 concentration levels varying from 10 to 100 mg./l., and at 4 flow rates varying from 400 to 2,000 ml./day. Biological activity was minimized by heat treatment of the soil before testing. An effort was made to keep the Reynolds number within the laminar range so that turbulence would not disturb the adsorption process. At these low flow rates, contact time between the soil particles and the solution is relatively long, enhancing the adsorption process.

Effluent solutions were analyzed bimonthly and breakthrough curves were obtained for all the columns. Thus adsorptive capacity of the soil was determined for different flow rates and concentrations.

Nitrogen Contamination of Ground Water

The likelihood that the effluent from any one of these treatments for liquid manure might be put into a lagoon or pond for further treatment gave rise to a study of the effects of ground water on the movement of nitrogen in soils adjacent to such bodies of waste water. Ground water contamination by nitrogen is greatly affected by the adsorptive capacity of the soil. To study the extent of such contamination, observation wells were installed in the vicinity of duck farm waste stabilization ponds. The wells were installed across the ponds in the apparent direction of ground water flow by inserting polyvinyl chloride pipes 1.25 inches (3.18 cm.) in diameter into 4-inch (10.2-cm.) holes and then back filling the holes with the original soil.

These studies, which are still in progress, consist of bimonthly determinations of water depth and removal of water samples. The samples are analyzed within 24 hours for ammonia nitrogen, pH, BOD, solids, and coliform. Since adsorption is the chief mechanism for controlling nitrogen flow through the soil, the adsorptive capacity of the soil will affect the length and time of travel of these nutrients. Adsorption data obtained in laboratory tests under natural flow conditions are being used, together with these field evaluations, to develop analytical expressions for predicting the effects of time and concentration on the movement of nitrogen through the soil. Beyond this, the hazards of ground water pollution might be predicted in general, if nitrogen concentrations and soil characteristics are known.

AN ASSESSMENT OF THE AGRICULTURAL AND PROCESSING WASTE PROBLEMS AND CONTROL IN WEST VIRGINIA

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Pollution of air, water, and soil from agricultural sources is not yet a serious problem in West Virginia, but it is growing. Legislative acts delegating authority for the control of all sources and types of pollutants, including those of agriculture, are vested in several State agencies.

Some statistics are necessary in order to place in proper perspective the relative magnitude of the agricultural waste problem in West Virginia, so comparisons may be made with other States in the Northeast. Then we want to outline the agencies responsible for administering the laws regulating pollution control, abatement, or prevention.

The area of West Virginia is approximately 15 million acres of which roughly 10 million acres are considered forest and 5 million acres are agricultural land. The population is about 1.8 million.

The agricultural industry includes beef, dairy, sheep, swine, poultry, and fruit with a few vegetable crops. Approximate total numbers and largest concentration are shown in table 1.

TABLE 1.--Farming enterprises in West Virginia

Enterprise	Total	Largest concentrations
Beef	382,000 head	600 head (feedlot)
Dairy	93,000 head	300 head (cows)
Sheep	180,000 head	400 head
Swine	71,000 head	320 head (sows)
Poultry		
Layers	1,500,000 head	50,000 head
Broilers	17,500,000 head	80,000 head
Turkeys	600,000 head	300,000 head
Fruit	1,170,000 trees	1,500 acres
Vegetables	2,000 acres	400 acres (sweet corn)

Agricultural people do not consider pollution from agricultural operations to be a serious threat in West Virginia at the moment, but some are apprehensive and concerned that it could be in the future. The steady influx of people from dense urban areas of the East who are buying land for second homes and retreats may substantially change the situation. It is expected that farm enterprises such as feedlots and broiler operations will increase in size and concentration.

What is beginning to happen in West Virginia has already happened in other areas of the Northeast. Through research and action programs, it may be possible to prevent, or at least keep within acceptable limits, pollution from agricultural operations. There are lessons to be learned from others who are already deeply involved in the elimination, or at least in the reduction, of pollution. Obviously it is easier to prevent pollution and contamination before it starts than to stop it after it has started.

Current Research

Current research on waste disposal in the West Virginia University Agricultural Experiment Station involves the disposal and utilization of manure from poultry in cages. This is a contributing project to the Northeast Regional Project No. 63. The objectives are to provide equipment and facilities that will dry the droppings as soon as possible after defecation to (1) prevent odors from developing, (2) prevent flies from hatching, and (3) reduce the volume and weight so that the manure can be stored, transported, and used with the least possible pollution of the environment.

Potential Sources of Pollution

Pollution from agricultural sources will remain as isolated cases in West Virginia for some time to come. Of some concern in the fruit area of the Eastern Panhandle and in the Shenandoah Area in general is the proper disposal of outdated pesticides and empty containers.

The beef cattle industry has grown steadily for many years. It is expected to continue to grow. If it does, there will be larger feedlots and brood herds. Likewise, laying flocks and broiler operations will grow in size to remain competitive and economical.

Although forest operations are not usually considered agricultural, they must be in West Virginia where forest land makes up a large portion of the farm acreage. Harvesting forest products require roads. These roads are usually poorly designed, constructed, and maintained, causing considerable erosion. Thus heavy sedimentation occurs downstream. Forest fires, certainly a source of pollution and resource destruction, frequently involve agricultural resources.

Other Sources of Pollution Affecting Agriculture

Everyone will agree that heavy industry concentrations are major sources of pollution of every description and may affect agriculture. In West Virginia and neighboring States, surface and deep coal-mining operations involve agricultural operations. Both industries may embrace the same land. Mine wastes in the form of acids and alkalines have made the water in many streams unfit for animal consumption. On one farm near Morgantown, the only water supply available for livestock in late summer comes from a stream flowing from an abandoned deep mine. The water has a pH of 2.4. Granted this pollution is not created by agriculture, but it is frequently on agricultural land, so farmers must be concerned about it.

Sedimentation has been a serious problem for many years in the Mountain State. Improper agricultural practices have contributed some sedimentation, but most of it comes from urban developments, highway construction, and forest and surface mining roads and surface mining operations. Most areas of West Virginia would be relatively free of pollution if it were not for sedimentation and coal-mining wastes.

Regulatory Agencies

Three principal State agencies are charged with the responsibility of enforcing State laws regarding pollution. These are the State Board of Health (Department of Health), the Department of Natural Resources, and the Air Pollution Control Commission.

The State Board of Health has supervision and control over the Department of Health. Quoting from Paragraph 1267 of the Public Health Laws (1961 publication, page 8):

> It shall have the power to inspect, and to make and enforce, for the protection of the public health, reasonable rules and regulations to control the sanitary condition of all institutions and schools, whether public or private, public conveyances, dairies, creameries, slaughter houses, work shops, factories, labor camps, places of entertainment, hotels, tourist camps, all other places open to the general public and inviting public patronage or public assembly, or tending to the public any item for human consumption, and places where offensive trades or industries are conducted... It shall have the power to inspect and to make reasonable rules and regulations to control the sanitary condition of streams, sources of water supply, and sewerage facilities.

The Department of Natural Resources is responsible for administering the Water Pollution Control Act and the 1967 Surface Mining Act.

Water Pollution Control Act

> Declaration of Policy:
>
> It is declared to be the public policy of the State of West Virginia to maintain reasonable standards of purity and quality of the water of the State consistent with (1) public health and public enjoyment thereof; (2) the propagation and protection of animal, bird, fish, aquatic and plant life; and (3) the attraction, development, maintenance, and expansion of agriculture, mining, manufacturing and other business industry.

Surface Mining Act

The Department of Natural Resources Surface Mining Act is:

> . . . hereby vested with jurisdiction over all aspects of surface mining and with jurisdiction and control over land, water and soil aspects pertaining to surface mining operations, and the restoration and reclamation of lands surface mined and areas affected thereby.

The Act created a Division of Reclamation in the Department of Natural Resources. This division:

> . . . shall have within its jurisdiction and supervision all lands and areas of the State, mined or susceptible of being mined, for the removal of minerals and all other lands and areas of the State deforested, burned over, barren or otherwise denuded, unproductive and subject to soil erosion and waste. Included within such lands and areas shall be lands seared and denuded by chemical operations and processes, abandoned coal-mining areas, swamplands, lands and areas subject to flowage easements and backwaters from river locks and dams, and river, stream, lake and pond shore areas subject to soil erosion and waste.

Air Pollution Control Commission

The Air Pollution Control Commission is responsible for administering the Air Pollution Control Law of West Virginia. Its declaration of policy and purpose are:

> It is hereby declared to be the public policy of this State and the purpose of this article to achieve and maintain such levels of air quality as will protect human health and safety, and to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this State and facilitate the enjoyment of the natural attractions of this State.
>
> To these ends it is the purpose of this article to provide for a coordinated State-wide program of air pollution prevention, abatement and control; to facilitate cooperation across jurisdictional lines in dealing with problems of air pollution not confined within single jurisdictions; and to provide a framework within which all values may be balanced in the public interest.

In practice, no single regulatory body may have sole jurisdiction and responsibility regarding pollution. Herbicides and insecticides may get into the air or the water or both. If it is airborne, the Air Pollution Control Commission claims jurisdiction. If it is in the water, the Water Pollution Control Board in the Department of Natural Resources claims jurisdiction.

The Department of Health requires the farmer to obtain a permit to build a lagoon for animal wastes. It does not specify construction standards. It would become involved only if the effluent that might drain from the lagoon gets into the water supply.

Although the State Department of Agriculture does not have authority over disposal of agricultural and processing wastes, it cooperates with the other State agencies that are responsible. It is presenting a bill to the next session of the Legislature, January 1971, relative to the control and use of pesticides.

Recently, the West Virginia Soil Conservation Service drafted a Standard for Management of Animal Wastes. This standard established the minimum acceptable quality for design and construction of disposal lagoon and holding pits and tanks located to serve predominantly rural or agricultural areas. Representatives from the Colleges of Engineering and Agriculture and Forestry, State Department of Agriculture, Federal Water Quality Administration, Agricultural Stabilization and Conservation Service, Cooperative Extension Service, and the State Department of Health assisted in the preparation of the Soil Conservation Service Standard. Also, the Department of Health has "tentative design criteria for loadings which may be used at places which desire to proceed with the construction of sewage stabilization ponds." These criteria are primarily for human sewage stabilization ponds.

Summary

Environmental quality has been sadly neglected until it now has reached grave proportions. It is creating major concern among all responsible people. The speed at which environmental quality has deteriorated far exceeds present efforts to stabilize or improve it. A famous engineer once said, "It is harder than hell to catch up with something that is going faster than you are." That is about the situation that exists today regarding pollution. It has been said that "You don't miss it if you never had it." It is time for more Americans to experience what it is like to live in an environment where the air, water, and soil are free of pollution. Then perhaps greater progress to improve the quality of the environment will be achieved.

A REVIEW OF METHODS FOR RECYCLING ANIMAL MANURES

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Every production system devised and built by man is a producer of waste. Only the quantity and kinds of waste produced and the extent to which the waste is harmful to our environment differ between systems. The agricultural systems involved in the production of food probably produce more waste than all the industrial systems combined. Fortunately for agriculture, this waste has been effectively managed, at least in the past, because most of it is biodegradable and has been distributed over large and often remote areas.

Public awareness of agricultural waste and the potential pollution problems that can be caused by poor management of this waste have grown tremendously. Besides knowing that our environment must be protected from pollution, the public should be made aware that food must be provided for a growing population. These facts are not inconsistent. Pollution of a natural resource or ecological system may be defined as the presence of a pollutant in such quantities that it is detrimental to the common uses of the resource or causes an unbalance in the ecological system. Realistic levels of potential pollutants in natural resources must be established to protect our environment, but these levels must also be consistent with the efficient production of our agricultural systems.

Proper management of agricultural waste can be accomplished with our present technical knowledge. The real problem faced by our agricultural producers is whether the cost of systems that are technologically feasible and safe in respect to pollution will make food too expensive for the consuming public. Every dollar spent to dispose of a ton of manure for hogs in total confinement systems, for example, will eventually raise the cost of pork at the market place by approximately one cent per pound, assuming there is no economic return from the manure.

It has been estimated that livestock in this country produce the equivalent waste of a population of 1.9 billion persons (1). Most of this waste is widely dispersed over fields and ranges. The equivalent waste of 201 million persons is produced in large-scale confinement operations where wastes are not widely dispersed (3). This is approximately equal to the waste produced by the entire population of this country. This amount, which must be handled by mass management methods, is expected to double by 1980.

Techniques for disposal of solid animal waste have become quite varied in the past few years. This in itself is an admission of the bewildering state of confusion in which we find ourselves with regard to the disposal of large quantities of animal waste.

Extensive research is being conducted in agricultural waste management by agricultural engineers and other agricultural scientists at a number of universities. Also, several State and Federal agencies and private organizations are involved in this work. Drying and incineration are being tested as a management technique. Extensive research on odor control from manures has been initiated. By far the greatest amount of work is being conducted on systems and methods for microbial digestion of animal manures.

Recycling manures as a potential means of utilization of this byproduct of animal production is now being investigated. Several of the various systems being considered are suggested by the sketch in figure 1.

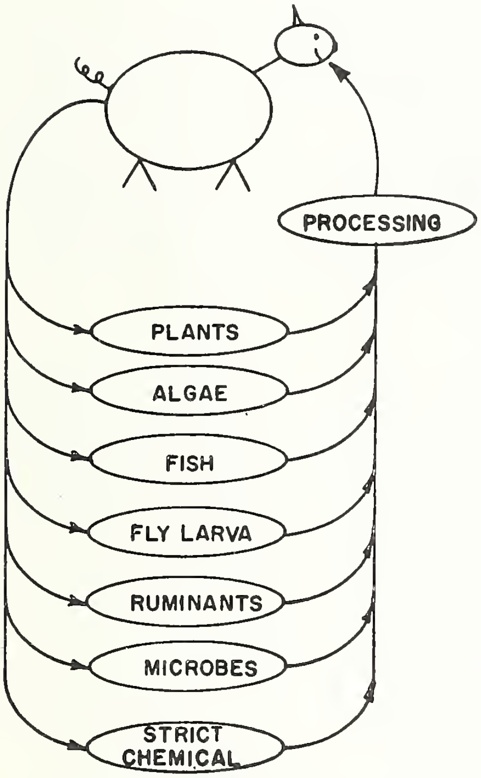

Figure 1.--Techniques used to recycle manures.

Recycling manures through plants is still the most widely used and perhaps the best means for sanitary disposal of large quantities of animal manures. This alternative should be considered in the design of any system, for it not only provides a means of disposal, but also adds nutrients to the soil estimated at a value of $2.50 to $9.00 per ton (7).

Algae production in aerobic lagoons and the subsequent use of algae as a feed material have been investigated by Hart (6). In such lagoons, algae grow in a symbiotic relationship with the aerobic bacteria. It was concluded that algae production from sewage and manure lagoons can be expected to be one of the most useful methods of reclaiming these wastes.

Fish can be grown on diets containing animal manures. This method of recycling can provide a high quality protein fish meal as a source of nutrients for animals. Durham et al. (4) have shown that catfish can make rapid gains on feedlot manure if care is taken to prevent oxygen depletion in the growing pond.

Biodegradation of animal manures by fly larvae may prove to be an efficient means of processing raw excreta. This system produces a fertilizer or soil conditioner and a feed supplement. Morgan et al. (8) have shown that wet poultry excreta can be converted to a crumbly waste in 8 days. Preliminary experiments by them indicate that the excreta from 100,000 hens can produce between 500 and 1,000 pounds of pupae daily. When dried, the pupae provide a satisfactory source of protein for growing chicks.

Fontenot et al. (5) have shown in a feeding trial that the rate of gain and carcass grades were not significantly different for beef steers fed mixtures containing 25-percent ground peanut-hull or wood-shaving broiler litter than for those fed a conventional fattening mixture. Feed efficiency was greater for the litter-fed steers. Anthony (2) has shown that feedlot manure can be blended with coastal bermudagrass hay to make a palatable and nutritious low-moisture silage. Durham et al. (4) have shown that all-concentrate cattle manure can be fed successfully to growing pullets and laying hens.

The Agricultural Engineering and Animal Sciences Departments at the University of Kentucky are presently engaged in research to determine if high-protein feeds can be made by fermenting fresh poultry manure with rumen microbes. The extent to which these manure feeds can be recycled to the poultry that produced them will be determined. Also, work is under way, or is being planned, to determine if usable nutrients can be produced or extracted from manures by strictly chemical, thermal, or physical processes.

Summary

The agricultural industry has many critical waste management problems. Many new practices and concepts are being tested and researched in an effort to solve these problems. These problems will be solved and new problems will develop. Theodore C. Byerly, Assistant Director of Science and Education, U. S. Department of Agriculture, has written (3):

> "... in the face of the environmental crisis confronting us - our value choices demand more caution, more refinement than ever before. As we attempt to resolve the problems of pollution, the systems we choose must not only be technologically effective but also socially and economically acceptable.

This is our assignment. No one will escape being involved in it."

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THE ROLE OF AGRICULTURE IN THE QUALITY OF THE NEW HAMPSHIRE ENVIRONMENT

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By way of introduction, I should probably tell you something about New Hampshire. Judging from my own knowledge prior to 1966, there may be those who, having visited neither, know more about Europe than they do about northern New England.

So far as agriculture is concerned, one can only stand in awe that our ancestors were able to eke out an existence in so unfavorable an environment. In many areas of New Hampshire, the soil is shallow and rocky. The majority of New Hampshire's land area is too hilly to support an economically viable agricultural operation. A large portion of the remaining area is too wet to farm. Add to this a New Hampshire taxation law under which assessment is based on highest potential use, recognizing no difference between urban and rural land areas, and we find that the agricultural areas in New Hampshire are rapidly being converted to vacation home sites, recreation uses, or are being allowed to revert to forest land.

Whereas 100 years ago over 50 percent of the land area was farmed, in 1967, 75 percent was in privately owned forests, and another 12.1 percent was under Federal ownership--most of this also being forested (Table 1). The Soil Conservation Service classified only 4.1 percent of the land area as cropland. The 1970 inventory by the Bureau of Markets indicates that in 1969 crops (including hay, fruit, and vegetables) were actually harvested from only 157,537 acres, or 2.7 percent of the land area.

As expected from the amount of land under forestation, New Hampshire's wood industry is a major employer in the State. As recently as 1968 this industry employed 13 percent of all workers engaged in manufacturing. It is fortunate that the wood industry has traditionally been separated from the agricultural industry, because some serious pollution problems arise from pulp mills and sawmills, as well as from the harvesting operation itself. Agriculture is receiving enough pressure for its role in environmental deterioration without including these additional problems. However, as cultivation and fertilizer techniques are adapted to use in forest culture, this separation may disappear.

TABLE 1.--New Hampshire land use in 1967, from New Hampshire Conservation Needs Inventory

Land use	Acres	Percent
Cropland*	234,796	4.1
Pasture land	60,606	1.1
Forest land *	4,345,100	75.3
Federal land	699,477	12.1
Water areas**	34,308	0.6
Urban and built-up areas***	169,159	2.9
Other land	225,132	3.9
Total land area	5,768,578	

*Forest land is defined as having 10 percent or greater canopy. Abandoned fields with less than 10 percent canopy are classed as cropland.

** Of less than 40 acres and streams less than 1/8 mile wide.

*** Areas of more than 10 acres such as cities, villages, and other built-up areas; also includes industrial sites, railroad yards, interstate highways, etc.

Agriculture in New Hampshire has been traditionally equated with dairying. In speaking to oldtimers, it quickly becomes evident that whatever vegetable growers, or even beef breeders are doing, they are not farming. Despite the relatively small amount of land devoted to farming, there are some current or incipient pollution problems associated with agriculture. Most of the farming operations are being conducted on the sandy soils of the narrow river valleys and the coastal area. The opportunity for pollution of both surface and ground water in these areas is a real danger.

For various reasons, fruit and vegetable farming has been of minor importance. However, this may be changing. The steady increase in tourism is encouraging the establishment of roadside vegetable stands, and the New Hampshire climate appears to be well suited for apple production. In addition, an attempt is being made to establish a grape-growing area at the higher altitudes of the lakes region.

New Hampshire has a minor animal industry when compared to many States (Table 2). Small animals may be important in some very local areas,

TABLE 2.--New Hampshire population and animal inventory and animal wastes in terms of human waste equivalents, January 1, 1970 (Bureau of Markets)

Item	Number	Approximate human waste equivalent
Population		
Resident (1970 census)	738,000	---
Nonresident (avg. daily)	63,000	---
Total	801,000	
Animals		
Cattle, calves, steers, bulls	73,000	730,000 - 1,095,000
Poultry	1,819,000	180,000
Sheep, lambs	5,700	3,000 - 6,000
Swine	1,300	1,000
Turkeys	6,600	600
Total	1,905,600	914,600 - 1,282,600

but, in general, their impact is negligible. There are no large swine feeding operations such as those in Illinois and Iowa; most hogs are scattered across the State, a few to a farm. The sheep are largely confined to small operations in the hillier regions, away from major streams and population centers. Poultry may be more noticeable, since most operations are near population centers where problems are encountered with proper waste disposal, and more noses are present to detect and react to the odors usually associated with poultry.

Cattle may contribute appreciably to the agricultural waste problem. It is obvious that waste produced by cattle in New Hampshire is roughly equivalent to that produced by the entire human population of the State. Fortunately, we do not have the cattle waste concentration found in some States, since we do not have the large feeding or dairy operations. (Few dairy herds exceed 100 head, and the majority are less than 30 head. But this also means that mass waste disposal systems will be uneconomical. The cattle are generally confined for about 8 months of the year, and the waste distributed on the land. Since the ground is frozen for 5 to 6 months of the year, this waste may be a source of stream pollution. An education program is decreasing the amount of manure applied to frozen ground, but the practice does persist. The University is setting a poor example in this respect, since it continues spreading some manure throughout the winter. This practice is particularly troublesome when surface drainage is necessary. The University did discontinue use of one surface-drained area when the stream feeding the Durham water supply started to run brown in the spring.

The stockpiling of wastes, however, does not automatically alleviate their potential for pollution. Piles of manure surrounded by spring flood water have been reported along the Merrimack River. (There is the danger, of course, that the water is contaminating the manure, rather than vice versa.) The traditional New England barnyard is frequently bisected by a small stream, and a pile of manure outside the barn door, under the eaves, completes the picture. There is little doubt that drainage from these piles enters the surface water supply.

Farmers and processors are having certain problems arising not so much from the waste itself as from some sanitarians' refusal to accept the fact that septic systems are not universally the best disposal system. The word "lagoon" is completely taboo in their vocabulary, due, in large part, to an unfortunate incident which occurred several years ago. A large broiler operation was installed near Rochester, with the waste handled in a lagoon. The lagoon, however, was too small, and quickly went anaerobic. To illustrate the degree of the problem, the pond was 1/4 acre, whereas the county agricultural extension agent estimated that a 20-acre pond was needed. As if the smell weren't enough, the dam broke, flushing the contents of the lagoon through a housing development. The owner promptly decided that the climate in Brazil was more to his liking. The word "oxidation pond" is somewhat more acceptable, but the structure still has generally not been acceptable as a waste disposal method. In one specific example of this problem, a small turkey processing plant near Kingston has been required to install a septic system to meet the new USDA standards for meat-packing plants. In this case, an oxidation pond might have been a better choice. It is probable that, sooner or later, undigested fats will clog the septic system.

Another serious waste-disposal problem arises in the large milking parlor. What do you do with the vast quantities of liquids containing milk, detergents, disinfectants, and some solids? Many dairymen are apparently required to use an installation approximating a septic system, in which one or two tanks are installed along with some type of leach field. With the volume of liquids involved, however, the tanks usually serve as little more than settling tanks. Perhaps too typical of the systems being used is one in New Hampton which came to the attention of a milk inspector. This dairyman had a dry well just outside the milking-room door. The dry well could not handle the load, and was overflowing. In this case, the farmer's solution was to install a pipe and deposit the overflow about 100 feet away in the pasture. Under our current laws, this solution had to be considered satisfactory, and in fact, if a manifold were included to spread the waste, it might be the most satisfactory disposal method.

In one respect, New Hampshire is fortunate. The majority of our milk goes to Boston for processing, taking with it the associated problems of processing waste disposal. As of November 2, 1970, only one processor was under a cease-and-desist order from the pollution control commission. This plant sells about 3,500 quarts of milk and milk products daily, and was discharging about 3,500 gallons of waste daily into a classified stream.

The problem of nutrient pollution as a result of fertilizer use has not been examined, and is probably rather unimportant compared to other sources of nutrients. However, there is definite room for improvement in our methods of fertilizer application. Approximately 16,000 acres are planted in field corn each year. To this, an average of about 120 lb. N is applied per acre. Virtually all of the N is applied two weeks before planting to two weeks after planting. There is no information on how much, if any, of this N gets into ground water or is washed off into surface water. However, the potential for ground water pollution is great, since the N is not applied at the period of maximum utilization by the corn plant. Most P and K is still being applied in the spring as mixed fertilizer. However, many fertilizer companies are pushing for fall application of P and K. There is no argument with this practice providing the fertilizer is plowed down, but probably no more than one-third is plowed down. The rest is either disked in or not incorporated, and is susceptible to loss by run-off during the winter.

The role of other potential pollutants is more difficult to ascertain. In general, the use of pesticides is being carefully policed, and the incidence of improper usage is probably small. The use of these pesticides is highly visible in orchards, but the extent to which fogging of fruit trees is a problem is unknown. Orchard owners are generally careful, and the noise pollution of early morning spraying may be more of a problem than the spray itself. However, it must be recognized that the 7 to 15 sprayings used each season does introduce a considerable amount of pesticide into the environment. Even though "hard" pesticides are no longer used, there is definite danger that heavy rains will wash the degradable pesticides into the surface or ground water supply before degradation is completed. Some concern has been expressed in respect to use of atrazine, the primary herbicide for corn. Although this compound may be considered a soil pollutant, its effect is not great, because most corn, by necessity, is grown in a continuous corn rotation. (New Hampshire is not overly blessed with land area suitable to growth of corn, and to modern harvest machinery.) DDT is licensed for use on sweet corn for control of ear worm. I received one unsubstantiated report of a grower spraying weekly with DDT. If true, this is improper usage, since corn ear worm outbreaks do not occur every year, and can usually be controlled by one application after they are noted. The weekly application sounds like the man standing on a New York street throwing papers in the air to drive away elephants. One certainly would not find corn ear worm if DDT is applied weekly.

The entrance of sediments into waterways is a real problem in some parts of the State, but this is more the result of construction than agriculture. The Soil Conservation Service is generally doing a commendable job in control of erosion from farmland.

Agricultural industry in New Hampshire is rapidly becoming a thing of the past. The leather tanneries and textile mills, once a mainstay of the economy, are gradually disappearing. The outdated factories can no longer compete with foreign and modern domestic production techniques. Nearly all of the fruit and vegetables produced are sold raw rather than being processed.

In the control of pollution from agricultural sources, the New Hampshire Cooperative Extension Service personnel have probably been the most important single factor. They are meeting with farmers, and are educating them to the role they must undertake. To date, little pressure has been put on agriculture, because of its minor role in the State. There are no control laws for agriculture beyond the general nuisance laws. The only practice which can be directly controlled is the direct and definite discharge of animal wastes into waterways. However, this situation will undoubtedly change, and as the municipal effluent is cleaned up, attention will shift to agriculture. It is incumbent upon agriculture to be ready for this pressure, and, if possible, remain ahead of it. The forest land in the State may be our saving grace. Several municipalities are beginning to look at the forests for possible sewage effluent and sludge disposal. It would also be ideal for animal waste disposal. The other problems may not be so easily solved.

Several people I talked to were very defensive about agriculture's role in pollution. This attitude, I think, is unwarranted. Certainly we recognized the problems long ago, and have been working hard at their solution. However, by becoming defensive at this point, we may forget that some problems still remain to be coped with. We should remain on the offense, and not be too concerned about those who are pointing the finger at us. After all, in the long run actions still speak louder than words.

REPORT FROM NEW JERSEY

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New Jersey is our most urbanized state and has, in the judgment of many qualified observers, some of the most stringent environmental quality control laws in the world. To continue farming and other agricultural enterprises within this framework is a major challenge to operators in the State.

Recognizing the need to provide answers to the problems of agricultural waste management, specifically, to take care of and to effectively utilize the more than 5,000 tons of agricultural wastes produced per day in New Jersey, the College of Agriculture and Environmental Science of Rutgers University is exerting a major research and education effort. The present research, utilizing about a third of our professional (scientific) manpower, involves many disciplines and covers specific projects directed toward pollution control. We feel that to consider waste as a resource is essential in any solution--"recycle" is the watchword. Projects recently completed and those presently active are given below:

(1) An inventory of animal solid waste in New Jersey to determine the magnitude of the problem and the disposal methods now being utilized has just been completed. The study was conducted in Burlington, Hunterdon, Monmouth, and Warren counties by our Department of Agricultural Economics and Marketing. Major financial support was provided by the New Jersey Department of Health with assistance from the New Jersey Department of Agriculture and from Rutgers.

(2) Our agricultural engineers, environmental scientists and soil scientists have collaborated on the development of equipment and procedures for disposing of solid and semisolid organic wastes in the soil in a project supported by the U. S. Public Health Service, HEW. Components of the equipment have been developed and demonstrations conducted to show that this plow-furrow-cover (PFC) technique, as it is called, can be used to dispose of organic wastes in an odor-free and pest-free manner. We do not as yet know the frequency of application and level of loading in the soil that is allowable without detrimental effects to the soil and ground water. Hopefully, a continuation of these studies can be funded.

(3) In addition, the agricultural engineers are working on rapid composting as a means of stabilizing the wastes resulting from feeding garbage to hogs. Composting should materially reduce the volume of waste and stabilize it for storage and ultimate utilization. Mechanical stirring is being used to accelerate the composting. This study is being made with the cooperation of the Agricultural Engineering Research Division of USDA's Agricultural Research Service.

(4) Our soil and field crop scientists are looking into the utilization of organic wastes and silt dredged from our streams and waterways to reclaim and increase the productivity of abandoned or underutilized lands such as former gravel pits, areas of the pine barrens, sanitary landfill cover, and the like.

(5) Our food scientists are progressing toward the development of an incinerable plastic bottle and the utilization of food packages and containers which are more readily disposable than those currently in use.

(6) Several plant biologists have been working for a number of years on plant responses to air contaminants, such as stack and engine exhaust gases.

(7) Our environmental science researchers have a number of projects on the treatment of domestic and industrial wastes to reduce pollution potential, and others covering water quality and treatment.

In the environment science area, the primary educational objectives at the College of Agriculture and Environmental Science are to apply the results of research to the solution of existing problems and to train people for careers in environmental science through degree-granting programs and short courses. Programs leading to the B.S., M.S., and Ph. D. degrees are offered in many areas of specialization from air resources and aquatic biology to waste water treatment and water resources. The nondegree programs include short courses and conferences in a wide variety of specialty areas such as environmental law, communications, and microscopy; incineration; community and industrial noise pollution; and urban environmental management.

EFFECT OF ORGANIC RESIDUES AND HERBICIDES ON WATER QUALITY

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Delaware's environmental problems are similar to those of many Northeastern States. In the northern part of the State, the major urban area, the land is rolling, similar to other Piedmont areas, and the soils are heavy. Dairy farming is the major agricultural enterprise. As the population grows, however, less land will remain in agricultural use as farmland is taken over to meet housing and urban needs.

The southern 70-80 percent of the State is flat coastal plain, and the soils are lighter in texture. This area is intensively farmed. Most of 133 million broilers fed out in Delaware in 1969 were raised here. Large processing facilities for both poultry and vegetables are located in this area.

At present, State and Federal governments are developing programs for the elimination or reduction of pollution, as cited by the Federal Water Pollution Control Act and amended by the Clean Water Act of 1965. It appears that 1972 is the target date for implementation of standards affecting waterways in States. If standards are rigidly enforced, many food processors may be out of business unless economical means can be found to treat wastes effectively.

In 1954, the Delaware food processing industry withdrew an estimated 1.75 million gallons of water per day. Ground water withdrawn by all industry in 1954 was estimated at 13.6 million gallons per day, and ground water use for all purposes, was estimated at 30 million gallons per day. The 1958 census of manufacturers reports that the Delaware food and kindred products sector withdrew one billion gallons of water and produced one billion gallons of waste water annually.

A study of water utilization and management was made of vegetable processors in 1967. The objectives of this study were: (1) to determine the water requirements and the quantity and quality of waste water resulting from or required in the processing of vegetable products in Delaware; (2) to determine the factors affecting the water requirements and quality of waste water; and (3) to determine the costs of intake water, waste disposal, and waste treatment.

Water requirements and the quantity and quality of waste water were found to differ widely among plants producing the same product and between products during the 1967 season.

An increase in a plant's operational rate was found to increase the efficiency of water utilization, and to decrease the quantity of waste water per case. An increase in the case yield reduced the amount of the waste. The particular product produced had a major effect upon the quantity of water required and the strength of the waste. The degree of recirculation affected the quantity of intake water required and the quantity of waste water.

Water disposal costs ranged from 22 mills per case to 56 mills per case at plants treating greater than 75 percent of their waste water. A large percentage of water disposal costs was associated with the removal of solid waste.

A similar study of the poultry-processing plants was also made. Approximately 151.1 million pounds of byproducts and unrecoverable waste were created by poultry processors in Delaware during 1969. Fortunately, most of this is recovered and is used by poultry byproduct and rendering plants.

When the observations of all plants are combined, the highest volumes and per-unit amounts of biological oxygen demand (BOD) and suspended solids were produced by the eviscerating operation. Almost three times as much waste water was used in the evisceration operation as was used in the next highest operation, dressing. Evisceration produced almost twice as much BOD as any other operation. Dressing was the second highest producer in all three categories and scalding and chilling produced roughly the same amounts of water.

Per-unit volumes of main effluent varied considerably among plants. The two plants that used the most waste water discharged twice as much per 1,000 birds as the two plants with the least water wastage. The ones using the most also had the highest per-unit values for BOD and suspended solids. High waste loads could indicate inadequate blood removal and inadequate screening of solids prior to discharge from the plant.

In four of the plants, the eviscerating operation produced the highest volume of waste water, and the scalding operation was the largest producer in the other plant.

In two plants, the highest amounts of BOD and suspended solids were produced by the eviscerating operation and scalding was the largest producer in two plants. Dressing created the highest waste loads in the remaining plant.

Another study considered contamination of soils and water with herbicides. It showed that runoff of herbicide, in either the liquid or solid phase, is related to herbicide type, soil type, and rainfall pattern. Atrazine and Trifluralin were strongly adsorbed to all soils; however, Bromacil was less strongly bound. Well water samples at 15 feet showed no evidence of contamination in any case.

Work in other areas of waste management is still continuing as are studies dealing with specific chemicals used in agriculture production.

Animal science is working on the premise that the total amount of litter to be disposed of will be reduced by leaving the litter in the house for several cycles. Progress to date is encouraging and the work is continuing.

Agricultural engineers are just initiating a project dealing with animal waste treatment and disposal.

Agricultural engineers and agronomists are studying the effect of asphalt barriers on crop yields, water, and nutrient movement with hopes of increasing the efficiency of all materials.

Sulfur-coated urea, a slow-release fertilizer, is also being studied in field experiments. It is felt that it may prove very beneficial in improving crop yields and fertilizer efficiency and that it may reduce the pollution potential of nitrogenous fertilizers.

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